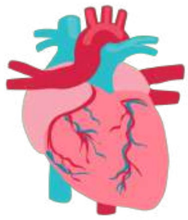
OBSERVER MEDICAL STUDENT REPORT

CASE WESTERN RESERVE UNIVERSITY/ UNIVERSITY HOSPITALS

DIVISION OF CARDIAC SURGERY

1st of July–27th of July 2024



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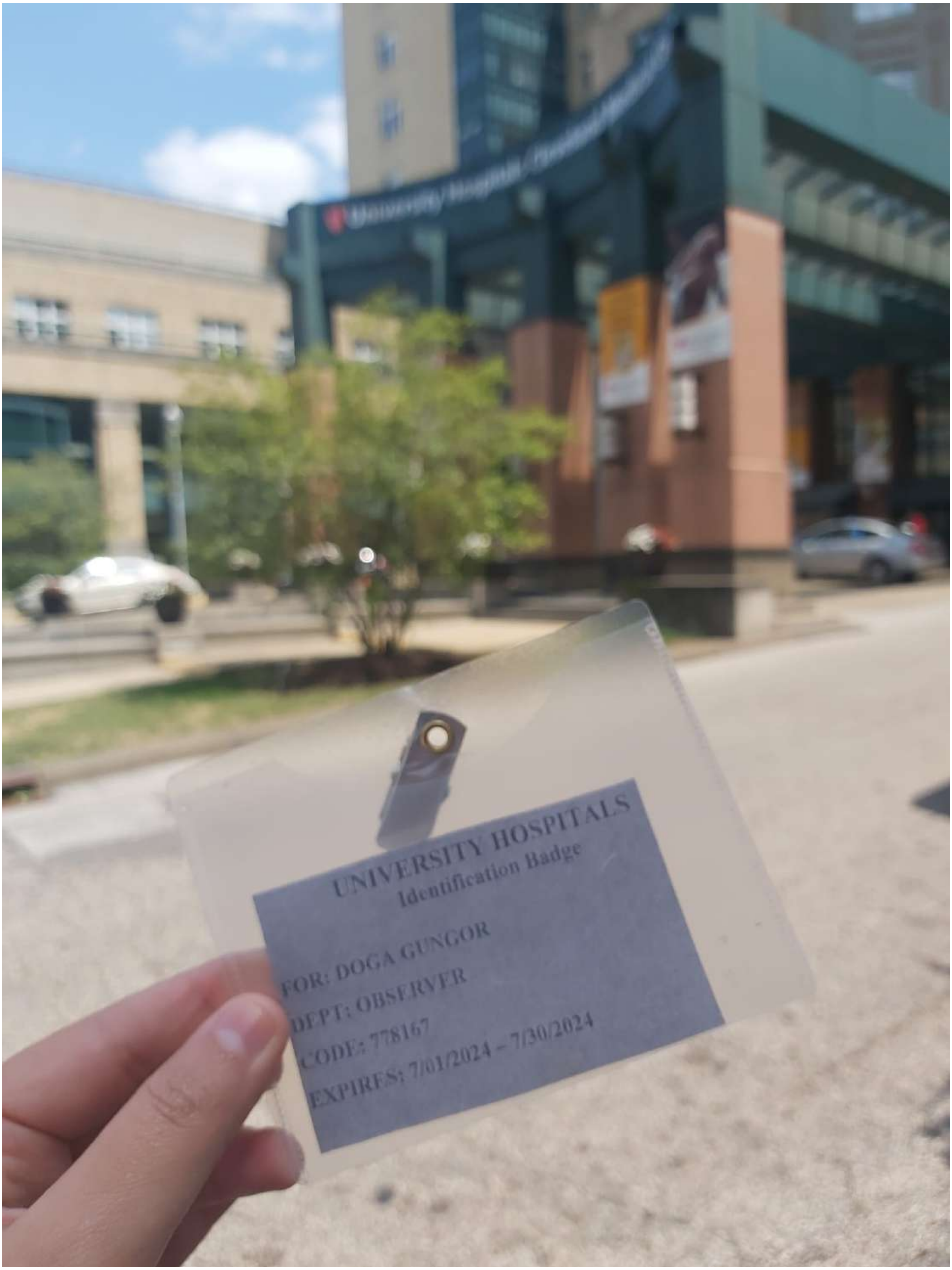
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WEEK 1

DAY 1 (July 1st 2024)

Since it was my first day, I wasn't given a timeline so I went to the hospital at 8 am. I met Mrs. Seymour, who dealt with my paperwork for this observership. I picked up my badge and asked them if I could meet some doctors because Dr. Pelletier (my supervisor) would arrive at the hospital tomorrow. They introduced me to Dr. Papus Keita. He kindly told me that my paperwork wasn't ready to get into OR today. Instead, I had a chance to spend some time with a practitioner nurse who does a follow-up for post-op patients. PN Mary and I talked about the basics and differences here in the US for taking patient notes. We talked about multiple different topics: She told me that prescribing opioids takes 3 stages. First, you order it like any other medication. Then you have to check the patient history for the last use of this medication. At last, you go through a fingerprint authorization stage which you do with an app on your phone. She showed me the huge screens where they constantly check the patients' HR and BP.

After we finished writing the patient progress notes, we did rounds. She had five patients today and we saw all of them. She asked them a couple of questions:
-> Are you eating okay?
-> Are you feeling well?
-> Did you pass a gas? (One of the patient had an ileus which was interesting to see)
-> What are your cardiologist's, cardiac surgeon's, and PCP's names?
-> Which pharmacy do you use?
I asked her about the last question and she explained that in the US, you can only pick up your medication from the pharmacy that you declare to the hospital and they send your prescription only to that specific pharmacy.
Then she performed PE on every patient. They all looked fine and we even discharged one of them. We had to remove the wires before sending him home. I asked PN Mary about the wires, and she showed me the external defibrillator to tell me that every patient leaves the OR with one of these attached to their heart in case it needs to be shocked. After that, we filled out the discharge papers. She had to fill out every part about which medication he should take and which he should completely avoid taking. After we filled out the rest of the patients' progress notes, we were all done for today. I thanked her for today and left the hospital.

DAY 2 (2nd of July 2024)

Robotic Surgery CBAG

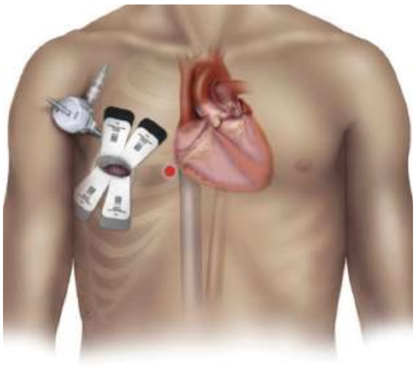
Today was an exciting day for me because yesterday I was told that I could watch a robotic surgery today. I went there at 7 to find Nurse Beth, who gave me scrubs and taught me how to get into the OR. After I got dressed they introduced me to Dr. Pablo Ruda Vega. After a lovely chat with him, we joined the rest of the team in the preoperative area to see the patient. He made him feel comfortable by talking to him about the procedure. Then, Dr. Vega showed me the Cath CT images of the patient who had a %45 occlusion in the LAD and a LVEF of 45%. I asked him whether the low EF would be a problem for the surgery but he explained it would only cause serious problems when it's less than 25-20 %. He said that he would dissect the LIMA with the Da-Vinci robot and do the rest on the operating table. There were 2 robots in the operating room and they let me watch the operation from one of them. It was a 3D image and felt amazing to watch. I could see the artery very clearly; being so close to it was magical. After LIMA was dissected, Dr Vega told me to scrub into the surgery more clearly to see what was going on. The surgery didn't require any CPB, so he completed the rest pretty quickly. He did a gold standard bypass, between LIMA and LAD, then they checked the blood flow quality with a Medi Stem flow probe. After everything seemed alright, they were done with the surgery. In the afternoon, Dr. Palletier had clinic so I went to meet him but it was cancelled and I went home.

DAY 3 (3rd of July 2024)

Minimally Invasive Mitral Valve Repair With Right Mini-Thoracotomy Approach

It was a late start day, so I came to the hospital around 7.40 to finally meet Dr. Pelletier. We talked about the surgery that he was going to perform. She was a patient with severe mitral regurgitation, but he mentioned that he would try to repair it first. We went down to the OR and he showed me her ECHO images.

The etiology of the mitral insufficiency for this patient was old age. This surgery was not going to be a standard sternotomy approach. He would do the cannulation from the femoral artery and vein following the right mini-thoracotomy. He would do a minimally invasive mitral valve repair. The patient was positioned in a supine position with a 45° elevated right hemithorax and retroflexed right arm. This allowed the expansion of the intercostal spaces, which facilitates the access. External defibrillation pads and a double-lumen endotracheal tube were applied. The body hair was trimmed, and antibiotic prophylaxis was given intravenously within 1 h of the skin incision.



The operating field was draped, and the skin was covered with a transparent film. CPB with vacuum-assisted venous drainage is established by either direct or percutaneous right femoral cannulation using the Seldinger technique placing the tip of a long venous cannula with multiple holes in the superior vena cava under transoesophageal echo guidance. Prior to the incision, the correct landmarks (sternum, xiphoid, jugulum, and fifth intercostal space) were identified and shown to me by the PA. The 6-cm incision was performed over the fifth intercostal space in the inframammary groove from the anterior to medial axillary line. Once the pleural cavity was reached, the anaesthetist discontinued right lung ventilation with the aid of the double-lumen tube. Once the CPB was established, ventilation was stopped entirely. Then, the pleural space was entered with special care not to injure the intercostal pedicle. When the soft tissue retractor was in place, the right hemithorax could be inspected. Ideally, the diaphragm is situated parallel to the sixth rib and does not obstruct the view of the heart through the fifth intercostal space. If the diaphragm is elevated, there might be the need for a retraction stitch which is anchored transthoracically. The pericardium was entered 2 cm anterior to the phrenic nerve. It was anchored transthoracically through thoracotomy. Then, the interatrial groove is dissected in a standard fashion. The patient was cooled to 34°C. The cardioplegia cannula was placed through the thoracotomy with direct puncture of the lateral aortic root. The atrial retractor was placed through a right parasternal incision. The aorta was clamped transthoracically and single-shot antegrade cardioplegia was given. After careful consideration, Dr. Pelletier decided to replace the valve and use a bioprosthetic valve since the patient was elderly. After the replacement, the Maze procedure was applied for A-Fib. After the closure of the atriotomy, epicardial pacing wires were placed on the right ventricle. Finally, the aorta was declamped. It is important to place the pacing wires before declamping because after that it is impossible to reach the myocardium. There was bleeding and the source wasn't identified at first but in minutes Dr. Pelletier found it and fixed it. One chest tube was inserted through the incision for the aortic clamp and fixed. The pericardium was also closed to avoid heart dislodgment and herniation.

After echocardiographic control of the surgical result, the patient was weaned from CPB and de-cannulated. Then the muscle, tissue, and skin were closed. That was the end of the surgery.

After this case, we went up to Dr. Pelletier's clinic to see his patients. Most of them were planned for a CABG and some were there for the first time. There was an interesting case in which the patient had constrictive pericarditis. It was a rare case to see and we had a chance to talk about it with Dr. Pelletier.
He explained that it was usually seen after a viral infection like syphilis but in developing countries, the reason was usually tuberculosis. In this case, the etiology was unknown so it was called idiopathic constrictive pericarditis. The patient stated that his symptoms started after a covid vaccine but Dr. Pelletier said that he was unfamiliar with this kind of side effect of the vaccine. After we saw all 5 patients, it was the end of the day for me.

DAY 4 (5th of July 2024)

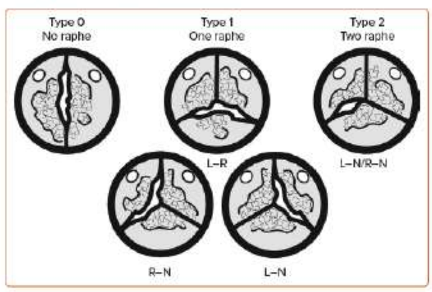
I joined Dr. Pelletier in the morning; it was a TAVR day for him. There were 4 cases in total but the first one got cancelled so we started around 11 am. I didn't go into the room for the first one, but I had a chance to watch it behind the glass. I joined the second one and Dr. Pelletier explained the whole procedure. Transcatheter aortic valve replacement (TAVR) is a procedure that replaces a diseased aortic valve with a man-made valve. It is usually preferred for aortic stenosis but also can be performed for aortic regurgitation. It is traditionally preferred for elderly or high-surgery-risk patients.

Aortic Stenosis

Stiffening, thickening/calcification of aortic valve (no longer opens fully during systole). Valve opening narrows and causes the pressure gradient increase across the valve. It ıs caused by:

- Mechanical stress (Old age) - Damaged endothelial cells over time → fibrosis and calcification
- Rheumatic heart disease - Repeated inflammation, repair → fibrosis → commissural fusion
- Bicuspid aortic valve

Figure 1: Bicuspid Valve Classification Using the Sievers Classification



L = left coronary sinus; N = non-coronary sinus; R = right coronary sinus. Source: Mylotte et al. 2014[34] Reproduced with permission from Elsevier.

Complications are heart failure, microangiopathic hemolytic anemia (red blood cells damaged as they squeeze through small valve opening), and Heyde's syndrome.

Patients are usually asymptomatic due to slow progression. Abnormal heart sounds like ejection click and Harsh crescendo-decrescendo systolic murmur can be heard at the upper sternal border, radiating to carotids. After it becomes symptomatic mortality increases extensively (Angina- 5 years, Syncope- 3 years, Heart failure- 2 years). The classic triad of symptoms is angina, syncope, exertional dyspnea. Additional heart sounds are soft, single S2/paradoxical S2 split; crescendo- decrescendo systolic murmur peaks later (the later the peak, the more severe the stenosis) and S4. Pulsus parvus et tardus (pulse weak, delayed) is one of the important characteristics of AS heard at the carotids. Narrowed pulse pressure is also seen.

Diagnosis can be made by:

- Transthoracic echocardiogram (TTE) -> Observe small aortic orifice during systole, the increased pressure gradient across the valve, left ventricular hypertrophy, calcification of the aortic valve

- Cardiac catheterization -> Useful for surgical planning (if the patient has concomitant CAD surgery would be a better option)

- Electrocardiogram -> Shows non-specific features of left ventricular hypertrophy

Three main criteria are used to identify the stage of AS: For treatment, medication therapy

Table 1. Classification of Aortic Stenosis Severity

Classification	*Transaortic velocity (m per second)*	*Mean pressure gradient (mm Hg)*	*Aortic valve area (cm²)*
Normal	< 2.0	< 10	3.0 to 4.0
Mild	2.0 to 2.9	10 to 19	1.5 to 2.9
Moderate	3.0 to 3.9	20 to 39	1.0 to 1.4
Severe	≥ 4.0	≥ 40	< 1.0

Information from reference 20.

can be used: Venodilators, calcium channel blockers, and beta-blockers followed by surgical valve replacement or TAVR if necessary

Surgery indications for AS are:

Patients with symptoms (spontaneous or on exercise test) and mean Doppler gradient ≥50 mmHg should undergo surgery	I	C
Patients with mean Doppler gradient <50 mmHg should undergo surgery when they have:		
• symptoms attributable to obstruction (exertional dyspnoea, angina, syncope) and/or	I	C
• LV systolic dysfunction (without other explanation)	I	C
• severe LVH, attributable to obstruction (not related to hypertension)	I	C
• when surgery for significant CAD is required	I	C

TAVR indications for AS are:

Indications	Contraindications
Severe AS with prohibitive surgical risk (STS PROM >8%) and >1-y expected survival	
Equivocal for age 65-80 y	Incompatible aortic annulus size (<18 mm or >29 mm)
Preferred in age >80 y	Active endocarditis Short distance between annulus and coronary ostium Age <65 y* Life expectancy <1 y

AS, Aortic stenosis; *STS PROM*, Society of Thoracic Surgeons Predicted Risk of Mortality; *TAVR*, transcatheter aortic valve replacement. *Relative contraindication.

WEEK 2

DAY 5 (8th of July 2024)

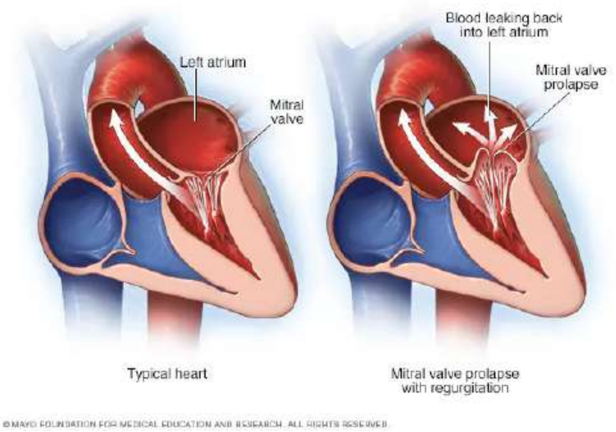
I joined Dr. Sabik and Dr. Keita on their mini-thoracotomy mitral valve repair case, which then turned into a replacement before the case started Dr. Keita explained the techniques used for repair and when to replace the valve. The patient was a 72-year-old male with a history of mitral valve prolapse that looked repairable on TEE.

Mitral Valve Regurgitation

- Mitral valve regurgitation is the most common type of heart valve disease. In this condition, the valve between the left heart chambers doesn't close fully. Blood leaks backward across the valve. If the leakage is severe, not enough blood moves through the heart or to the rest of the body. Mitral valve regurgitation can cause fatigue, arrhythmia, palpitations, and shortness of breath.

- **Types of Mitral Regurgitation**

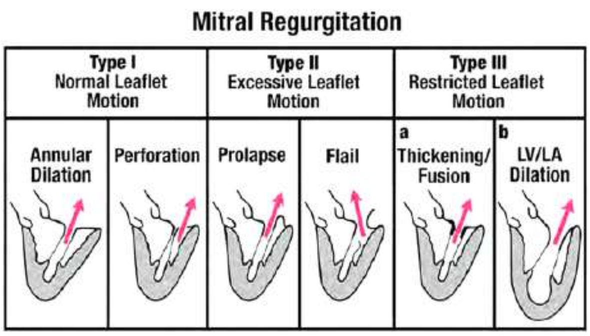
1. **Primary mitral regurgitation -** > Also called degenerative or organic. Resulting from the structural deformity of or damage to the leaflets, chordae, or papillary muscles, causing leaflets to close insufficiently during systole. Common causes are papillary muscle rupture, mitral valve prolapse (MVP), or leaflet perforation



2. **Secondary mitral regurgitation ->** Also called functional or ischemic. Due to left ventricular wall motion abnormalities (ie, ischemic cardiomyopathy) or left ventricular remodeling (ie, dilated cardiomyopathy). There are no structural problems with the valve itself. This leads to mitral annular dilatation or displacement of papillary muscles, causing retrograde flow from improperly closed mitral valve leaflets

- The Carpentier Classification divides mitral regurgitation into 3 types based on the leaflet motion:

    1. Type 1: Normal leaflet motion -> Caused by annular dilation or leaflet perforation and regurgitation jet directed centrally



2. Type 2: Excessive leaflet motion -> Caused by papillary muscle rupture, chordal rupture, or redundant chordae. Eccentric jet directed away from the involved leaflet

3. Type 3: Restricted leaflet motion ->

   IIIa: Leaflet motion restricted in both systole and diastole. Can be caused by rheumatic heart disease. Normal papillary muscles. Jet may be centrally or eccentrically directed

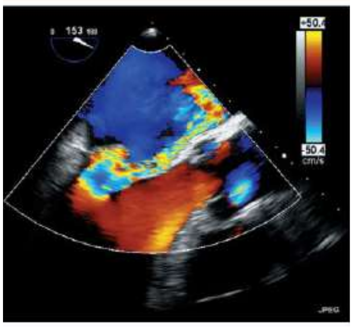
   IIIb: Leaflet motion restricted in systole. Caused by papillary muscle dysfunction or left ventricular dilation. Abnormal papillary muscles. Jet may be centrally or eccentrically directed

- The definition of MR is a retrograde flow of blood from the LV into the left atrium LA through the MV, causing a systolic murmur heard best at the apex of the heart, with the sound radiating to the left axilla. Mitral regurgitation leads to left ventricular volume overload due to increased stroke volume, caused by increased blood volume within the left atrium and an increased preload delivered to the left ventricle during diastole.

- In chronic progressive MR, ventricular remodeling occurs, allowing maintenance of cardiac output, and an initial increase in EF is usually observed. However, the effective EF can be considerably lower depending on the regurgitant fraction. Over time, there is a positive feedback loop by which volume overload from MR causes dilation of the ventricle, widening of the mitral annulus, and diminishing coaptation of leaflets, leading to progressive worsening of the MR.

- Eventually, volume overload becomes so severe that excitation-contraction coupling of the muscle membrane becomes impaired, and wall stress-related afterload on the left ventricle leads to dilation with decreased contractility, resulting in a reduction of EF. In addition, the regurgitant blood from the left ventricle during systole can eventually cause left atrial enlargement, impairment of left atrial contraction, and subsequent atrial fibrillation, leading to a thrombus in the left atrial appendage

- **Diagnosis**



1. Echocardiogram -> Echocardiography is the primary and essential diagnostic test for diagnosing and assessing mitral regurgitation. Transthoracic echocardiography and transesophageal echocardiography provide qualitative and quantitative analysis.

2. The Doppler volumetric method is also an option for quantifying MR. In the healthy heart, normal values are:

   ➔ Tenting height of less than 0.5 cm

   ➔ A tenting area of 0 cm^2

   ➔ Angles of the anterior and posterior mitral leaflet are less than 3 degrees

Poor outcomes after MV repair are defined as:

- ➔ Tenting height of greater than or equal to 1 cm
- ➔ Tenting area of greater than 2.5 to 3 cm^2
- ➔ Complex jets
- ➔ Posterolateral angle of over 45 degrees

3. Electrocardiogram -> Atrial fibrillation is the most common electrocardiogram finding in patients with MR
4. Chest Radiography -> In patients with chronic MR, cardiomegaly due to left-atrial or right-sided heart enlargement is visible on anterior-posterior x-ray views.
5. Exercise Stress Testing -> In patients with severe, asymptomatic, primary MR, exercise treadmill testing may provide information regarding the patient's symptom status and exercise tolerance. Exercise echocardiography is useful to assess changes in MR severity and pulmonary artery pressure in those symptomatic with non-severe MR at rest.
6. Cardiac Catheterization -> Cardiac catheterization can quantify MR volume with high accuracy when clinical findings are inconsistent with noninvasive test results.
7. Cardiac Magnetic Resonance Imaging -> Cardiac magnetic resonance imaging (MRI) is an important and complementary tool to other modalities for assessing the severity of MR. Cardiac MRI accurately assesses quantitative measurements, including regurgitant volume and regurgitant fraction.
8. Biomarkers -> In response to heightened wall stress, ventricular myocytes release the biomarker B-type natriuretic peptide (BNP), which correlates with symptom severity and offers prognostic insights for individuals with MR.

- **Treatment**

  The choice of medical versus surgical management of mitral regurgitation depends on the condition's severity, chronicity, comorbidities, and etiology.

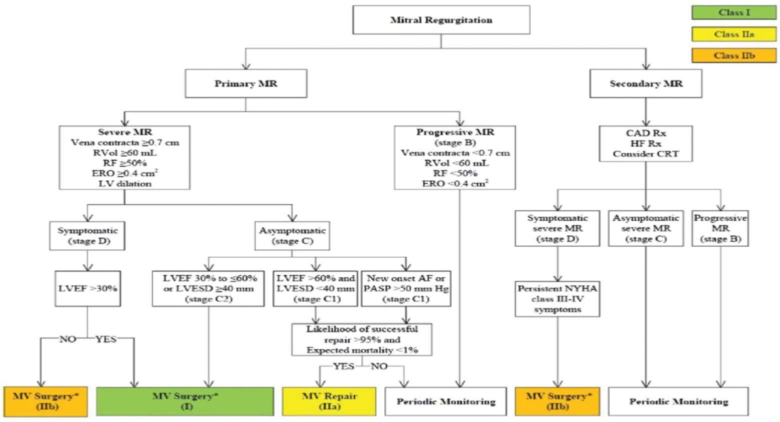
1. Medical Management of Mitral Regurgitation -> Angiotensin-converting enzyme inhibitors (ACE) and angiotensin II receptor blockers (ARBs) have been used in those who are asymptomatic to delay the progression of MR. The belief is that ACE inhibitors and ARBs can decrease regurgitant volume and LV size in patients with chronic primary MR
2. Surgical Management of Mitral Regurgitation -> The decision whether to operate is dependent on the underlying cause of MR. Patients with valvular damage due to chordal or papillary muscle rupture or infective endocarditis require surgery. Patients with functional causes of MR, such as ischemia, generally require coronary artery bypass grafting. Patients with acute, symptomatic MR or an EROA of at least 4 cm^2 require surgical intervention.

   Surgery for MR is indicated in patients with LV function deterioration or an end-systolic diameter of 45 mm. Patients diagnosed with primary severe MR require surgery when symptomatic with an ejection fraction over 30% or asymptomatic with an EF of 30% to 60%.

Mitral valve repair has 2 aims: An acceptable surface area of mitral valve leaflet coaptation and essential annular dilatation of 5 to 8 mm.

The ACC and AHA generally recommend mitral valve repair over replacement due to decreased recurrence of MR after repair. Available data reveal decreased morbidity and mortality after surgical repair over replacement. However, mitral valve replacement is favorable over repair when there is extensive tissue destruction, which can occur in some cases of infective endocarditis. Nevertheless, the newest AHA guidelines clearly state that “mitral valve replacement is preferable to a poor repair.” Concerning surgical replacement of the mitral valve, mechanical prostheses are usually preferable to bioprosthetics due to increased durability and less complicated insertion. Postoperatively, both types require anticoagulation, with bioprosthetic valve replacement requiring only temporary anticoagulation and lifelong anticoagulation with warfarin for mechanical valves.

Mitraclip is another surgical procedure proven to be effective and has low morbidity and mortality in patients considered to be at high risk for repair or replacement. Mitraclip can decrease the mitral valve area, leading to stenosis, and therefore, an area of under 4 cm^2 is a contraindication for this procedure



DAY 6 (9th of July 2024)

Today, I joined Dr. Sabik, and it was a complicated surgery. The planned operation was mitral valve replacement, tricuspid repair, and maze procedure. The patient was a 65-year-old woman with a medical history of AF, hypertension, and hyperlipidemia with severe mitral stenosis.

Mitral Valve Replacement and Tricuspid Valve Repair

1. A median sternotomy was performed and the pericardium was suspended from the chest wall with interrupted sutures. After administration of heparin, cannulation sutures were placed on the distal ascending aorta, superior vena cava, and right atrium for aortic and venous cannulae. Smaller purse strings were placed on the aorta and right atrium for the antegrade and retrograde cannulae. A third small purse string was placed on the right superior pulmonary vein for the vent. The operation is performed during a single period of aortic occlusion with moderate systemic hypothermia.

2. Standard central aortic cannulation and bicaval cannulation were performed. The small caval cannulae were placed directly in the superior vena cava and at the bottom of the right atrium to be well out of the operative field. Vacuum-assisted cardiopulmonary bypass was employed. Both antegrade and retrograde blood cardioplegia were administered for myocardial protection. Caval occlusion tapes and a small pediatric left atrial vent were placed, taking care to minimize manipulation of the heart to avoid embolization of debris.
3. The left atrial dome was exposed for future extension of the transseptal incision. This is performed by retracting the aorta leftward and freeing up the dome with sharp dissection from the aortic root. A generous portion of the dome was now available for the incision and eventual closure.
4. An oblique incision was made on the right atrium and extended over the top of the right atrium to the common wall of the right and left atrium. The incision can either be directed between the right atrial appendage and the superior vena cava or carried more medially between the right atrial appendage and the atrioventricular groove, staying well away from the area of the sinoatrial node.
5. The transseptal incision begins at the level of the fossa ovalis and runs superiorly to meet the junction of the right and left atrium. The incision was then extended out onto the left atrial dome. The incision was enlarged inferiorly by dividing through the interatrial septum to its reflection near the inferior vena cava. The transseptal approach is useful for patients with valvular disease involving both the mitral and tricuspid valves. This incision provides excellent exposure for addressing pathology on both valves and has the added advantage of extension up onto the dome of the left atrium if additional exposure is required. This exposure provides the ability to perform the full range of reparative operations or valve replacement with minimal heart distortion.
6. A self-retaining retractor with narrow blades was used to expose the mitral valve. Minimal traction and manipulation of the heart were required for excellent exposure. The large vegetation on the anterior leaflet was identified and the anterior leaflet was resected. The posterior leaflet was uninvolved and is routinely retained for structural support during mitral valve replacement.
7. Annular stitches were inserted in a mattress fashion, placing the pledgets on the atrial side of the annulus. The sutures were then placed through the sewing ring of the bioprosthesis in a standard fashion. The bioprosthesis was lowered into the position and the sutures were secured. The valve was inspected for proper alignment and suture integrity.
8. The transseptal incision was closed beginning on the left atrial dome up to the common junction of the right and left atrium. A second suture was begun at the inferior part of the interatrial septum and brought up to the first suture, closing the fossa ovalis.
9. The tricuspid valve was inspected and a single area of perforation in the inferior leaflet was identified. After debridement, the perforation was closed with interrupted suture. The valve was tested for competency with a saline injection. The valve was completely competent and therefore no further repair is required.

10. The right atrial incision was closed beginning at the junction of the left and right atria. A second suture was begun at the inferior aspect of the incision and brought up to the first suture to close the right atrium.
11. After the release of the caval occlusion tapes and the aortic cross-clamp, atrial and ventricular temporary pacing wires are placed on the surface of the heart. Separation from cardiopulmonary bypass and wound closure was performed in a standard fashion

DAY 7 (10th of July 2024)

In the morning, I had a chance to meet Dr. Halim and join his clinic. It was a TAVR clinic in which patients were evaluated by both cardiology and cardiac surgery doctors at the same time. Nearly all the patients were older than 75 years old with a severe AR which directly made them a better candidate for TAVR. Most patients have been experiencing shortness of breath and fatigue over the past few months. There was one patient who claimed to be asymptomatic, and Dr. Halim told me that in these cases if the patient has severe AR in ECHO, I should do a stress ECHO to see if the patient is asymptomatic or not.

After the clinic was over, he told me that he had a case in the afternoon if I wanted to join and I accepted. It was a redo aortic valve replacement, the patient had normal coronary function. Dr. Halim told me that redo surgeries should always be evaluated in case of the adhesions in chest wall. He looked at the chest CT to make sure he has safe space for sternotomy. He mentioned that they use a different type of saw for redo surgeries, which stops working when in contact with soft tissue.

AVR and TAVR

1- Aortic valve procedures may be performed through a full median sternotomy incision or a minimally invasive incision. These include an upper or lower sternotomy with a “J” or “T” incision into the third or fourth intercostal space or an anterior right second or third interspace incision. Cannulation for CPB for minimally invasive approaches can be performed either through the incision or using the femoral vessels. If the latter is planned, a preliminary abdominal-pelvic CT scan should be performed to assess for iliofemoral artery size, tortuosity, and calcification.
2- SAVR with either a tissue or mechanical valve has been the standard treatment for AS, but has been superseded by the use of transcatheter valves in most patients.

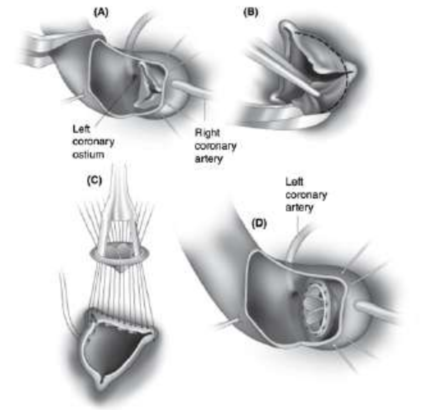


Figure 1.8 • Aortic valve replacement (AVR). (A) A transverse aortotomy incision is made and holding sutures are placed. (B) The valve is excised, and the annulus is debrided and sized. (C, D) Pledgeted mattress sutures are placed through the annulus and through the sewing ring of the valve, the valve is lowered to the annulus, and the sutures are tied. The aortotomy is then closed.

- Mechanical valves of bileaflet tilting disk design have virtually completely replaced single-leaflet tilting disk valves. They require lifelong anticoagulation with warfarin. Valve longevity is contingent on the development of complications such as thrombus formation or pannus ingrowth that impairs leaflet function, or the development of endocarditis.
- Tissue valves include porcine and bovine pericardial valves, all of which have various heat or chemical treatments to improve longevity. Rapid deployment valves are often considered to reduce cross-clamp times during complex operations or in older patients. These include the Sorin Perceval valve and the Edwards Intuity valves. They have similar valve leaflets but are designed for implantation with few sutures to expedite implantation. The lower segment of the valve frame may predispose to bundle branch blocks and complete heart block, the latter being noted in about 10% of patients.
- A stentless valve may be selected to provide a larger effective orifice area and may be placed in the subcoronary position or as a root replacement. Its primary benefit may be noted in the small aortic root
- The Ross procedure, in which the patient's own pulmonary valve is used to replace the aortic root, with the pulmonary valve being replaced with a homograft (basically a double-valve operation for single-valve disease), is an even more complicated procedure generally reserved for patients younger than age 50 who wish to avoid anticoagulation.

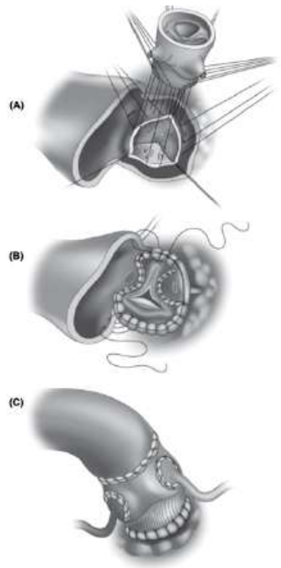


Figure 1.9 • Stentless valves have a larger effective orifice than stented valves, allowing for more

- Homografts are usually reserved for patients with aortic valve endocarditis, although other types of prostheses arguably provide comparable results.

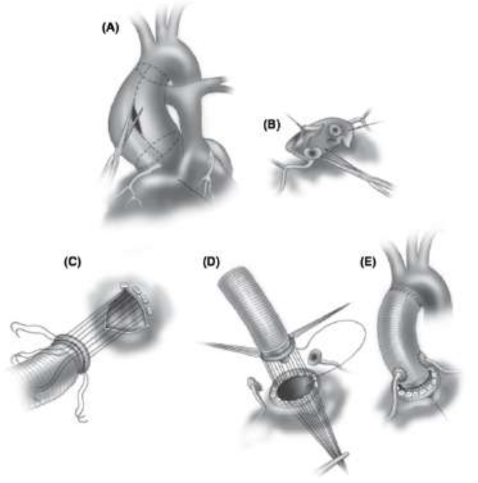


Figure 1.11 • Bentall procedure. (A) The aorta is opened and then divided proximally and

▪ An aortic root replacement, usually as a valved conduit, is indicated when the ascending aorta must also be replaced. If the sinuses of Valsalva are not dilated, replacing the aortic valve and using a supra-coronary graft simplifies the procedure. In younger patients, a commercially available mechanical valved conduit is selected. In older patients, a "bioroot" may be used to avoid anticoagulation. This is constructed by sewing a tissue valve into the proximal end of the Dacron graft.

3- Transcatheter aortic valve replacement (TAVR) involves the endovascular placement of a tissue valve mounted on a catheter delivery system. Although numerous valves have been designed and are being evaluated, the two most popular ones are the Edwards SAPIEN series, which is a balloon-expandable bovine pericardial valve, and the Medtronic CoreValve/Evolut series, which has a porcine pericardial valve within a nitinol self-expanding valve frame delivered within a sheath. Both of these systems can be used for stenotic native valves as well as stenotic or regurgitant bioprosthetic valves ("valve-in-valve" procedure).

- A CT scan is an essential component of the preoperative evaluation. The chest imaging will assess the aortic annular area and perimeter to determine the appropriate-sized transcatheter heart valve. The distance from the annulus to the coronary ostia is measured to ensure that native valve displacement does not obstruct the coronary ostia. This is especially important in valve-in-valve procedures.
- A BASILICA (Bioprosthetic Aortic Scallop Intentional Laceration to prevent Iatrogenic Coronary Artery obstruction) may be necessary in these procedures to avoid coronary ostial obstruction in patients with low coronary ostia. The abdominal-pelvic imaging assesses the size, tortuosity, and calcification of the iliofemoral vessels to determine whether a transfemoral approach is feasible
- The procedural risk is lower with a transfemoral approach (easy to put pressure in case of bleeding). If not feasible, subclavian imaging should be evaluated to assess for axillary/subclavian access which can be achieved via cutdown or percutaneously. Additional alternative access sites include transcaval, transaortic through a limited upper sternotomy, transcarotid, and transapical approaches. The latter was initially the approach of second choice, but was fraught with more complications, especially in elderly patients.
- Transcatheter valves have less stent frame width than surgical valves and are designed for optimal opening of the leaflets. This produces superior hemodynamics to surgical valves, especially in the small aortic annulus. Clinical outcomes in patients at high, intermediate, and low surgical risk are equivalent, if not superior, to SAVR. The major risks are those of stroke, estimated at around 2%, which might be reduced by use of a cerebral protection device and the necessity for a permanent pacemaker for complete heart block.

- With less deployment in the LVOT, this risk has been substantially reduced to less than 5%. This risk is greater in patients with a pre-existing right bundle branch block and a left anterior hemiblock.

4- Reparative procedures, such as commissurotomy or debridement, have little role in the management of critical AS. However, debridement may be considered in the patient with moderate AS in whom the valve disease is not severe enough to warrant valve replacement, but in whom decalcification may delay surgery for several years.

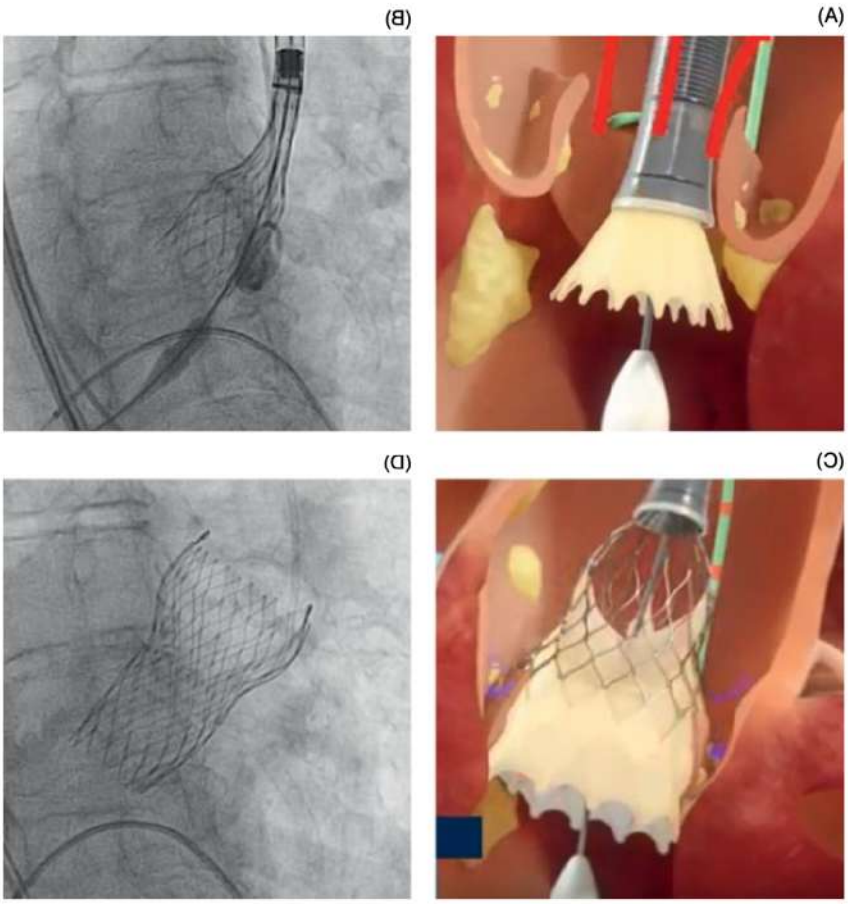
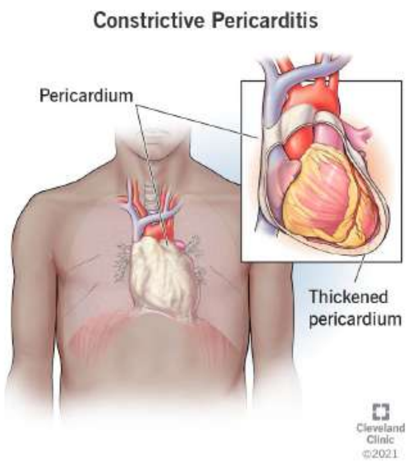


Figure 1.13 • Drawing and fluoroscopic images of a TAVR with a Medtronic Evolut Pro valve. (A, B) Partial self-expansion of the nitinol frame by withdrawal of the constraining sheath. (C, D) Complete valve deployment. (Image courtesy of Medtronic, Inc. (A and C)).

DAY 8 (11th of July 2024)

Today, I was with Dr. Halim, and he had an interesting case. The patient had constrictive pericarditis that required a pericardiectomy surgery. The surgery went well but after a few days' patient had a sudden cardiac arrest which caused him to go into ECMO machine. After a few days, I watched the chest closure surgery of the same patient, but his muscles were damaged. Dr. Halim told me that he could need a muscle graft in that area.

Constrictive Pericarditis

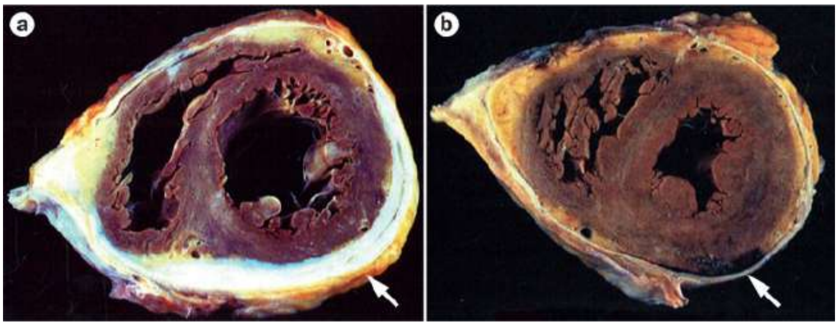


- The pericardium is the fibroelastic sac that covers the heart. Besides acting as a protective barrier, it also affects cardiac hemodynamics. Constrictive pericarditis is a condition in which granulation tissue formation in the pericardium results in loss of pericardial elasticity leading to restriction in the ventricular filling. It is usually a chronic condition however subacute, transient, and occult variants have been described.

- **Etiology:**
  - Worldwide, the leading cause of constrictive pericarditis is tuberculosis, and the incidence is about 50% of patients with tuberculous pericardial effusion despite antitubercular therapy. In developed nations, the leading cause of this condition is idiopathic or post-viral infection with incidence being 40% to 60% of total cases.
  - It is also a known complication of any cardiac surgery and is a fairly common complication of mediastinal radiation therapy with an incidence ranging from 2% to 30% in patients treated with radiation. It has also been associated with connective tissue disorders such as rheumatoid arthritis and systemic lupus erythematosus (SLE). The diagnosis of constrictive pericarditis may be fairly simple however most of the time it is much more difficult to establish a cause. In many cases, a cause cannot be identified and is attributed to be an asymptomatic episode of viral pericarditis.

- **Pathophysiology:**
  - Involves obliteration of pericardial cavity by granulation tissue during healing of an acute episode of fibrinous or serofibrinous pericarditis or resorption of chronic pericardial effusion. The granulation tissue gradually contracts over time and encases the heart and may get calcified. This rigid thickened pericardium limits the ventricular filling as the elastic limit of the diseased pericardium is much lesser than that of a normal pericardium.

- Ventricular filling in early diastole is not affected and is only impeded when the elastic limit of the pericardium is reached in contrast to cardiac tamponade where the ventricular filling is impeded throughout the diastole.
- This results in decreased end diastolic volume and decreased stroke volume and cardiac output. The thickened and scarred pericardium prevents the normal inspiratory decrease in intrathoracic pressure from being transferred to the heart chambers.
- There are dissociation intrathoracic and intracardiac pressures. This leads to decreased venous return with inspiration as pulmonary venous pressure decreases. However, the left atrium pressure does not, and pulmonary veins to left atrial (LA) flow decreases on inspiration. This intrathoracic and intracardiac pressure dissociation is a distinguishing feature from cardiac tamponade as in cardiac tamponade the changes in intrathoracic pressure are still conducted to the heart and there is an increase in systemic venous return with inspiration.
- In both disorders, there is equalization of the right atrial (RA), right ventricular (RV), left ventricular (LV), and pulmonary wedge pressure however cardiac tamponade the pressure decreases with inspiration whereas in constrictive pericarditis the RA pressure remains constant while the pulmonary wedge pressure decreases.



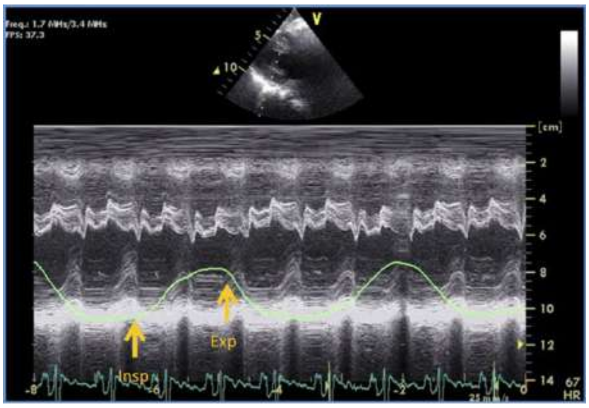
- **Presentation:**

  - Patients will often present with chronic symptoms. Their symptoms may be related to volume overload like weight gain and swelling or may be related to decreased cardiac output like progressive fatigue and dyspnea on exertion. They may also complain of increasing abdominal girth or abdominal discomfort. Abdominal complaints are secondary to either ascites or congestive hepatomegaly.
  - On physical examination, the jugular venous pressure (JVP) is usually elevated, however, may be normal in early constrictive pericarditis. JVP does not decrease with inspiration, and this is known as Kussmaul's sign.
  - Kussmaul's sign is also present in tricuspid valve disease, and right-sided heart failure.
  - Pulsus paradoxus (more than 10 mm Hg drop in systolic blood pressure during inspiration) can be seen however this is more common in patients with cardiac tamponade.
  - An accentuated heart sound heard earlier than third heart sound called pericardial knock can be heard in almost half of the patients.

- Abdominal examination may reveal ascites or hepatomegaly. Other signs of chronic illness like muscle wasting may be present based upon the etiology. Peripheral edema may be present as well.

- **Diagnosis:**

  - **ECHO Cardiography:**
  - The American College of Cardiology and the European Society of Cardiology guidelines recommend the use of echocardiography for diagnosis of constrictive pericarditis and any other pericardial disease. Two-dimensional echocardiography may show increased pericardial thickness with or without calcification. Two-dimensional echocardiography may also reveal dilatation of the inferior vena cava with the absence of inspiratory collapse. A sharp halt in diastolic filling may be seen along with the abrupt transient movement of intraventricular septum towards the right side which is also known as septal bounce.



  - An absence these features on ECHO makes the diagnosis of constrictive pericarditis very unlikely.
    1. Posterior motion of ventricular septum on early diastole in inspiration
    2. Absence of increase in systemic venous return with inspiration
    3. Premature opening of the pulmonic valve due to higher right ventricular diastolic pressure compared to pulmonary arterial pressure

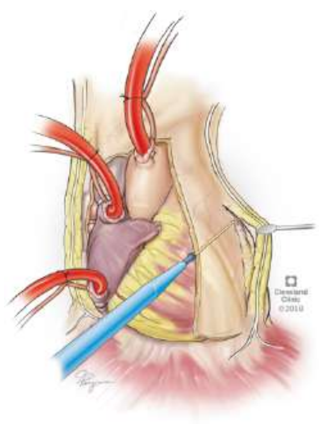
  - Doppler ECHO is used to evaluate hemodynamics of the disease and may reveal the following:
    1. Abnormal passive filling of the ventricles in early diastole
    2. Increase in diastolic flow velocity across the tricuspid valve during inspiration and decrease during expiration
    3. Exaggerated reduction in flow velocity in the pulmonary veins and across the mitral valve in inspiration and a leftward shift of ventricular septum
  - **Electrocardiogram:** There are no specific signs of constrictive pericarditis on ECG which may reveal nonspecific ST changes and low voltage. Advanced and long-standing cases may show atrial fibrillation secondary to elevated atrial pressures.

- CT scan and cardiac MRI are also frequently done especially before surgical management of constrictive pericarditis. These can reveal thickened pericardium and the presence of calcifications. CT scans can detect calcifications better compared to cardiac MRI. Cardiac MRI is better to differentiate small effusions from pericardial thickening. Myocardial fibrosis or atrophy seen on CT or MRI is associated with a poor surgical outcome.
- Occasionally patients undergo right heart catheterization for hemodynamic studies which may reveal increased right atrial pressure, increased RV end-diastolic pressure, prominent x and y descent on venous and atrial pressure tracings and greater inspiratory fall in pulmonary capillary wedge pressure compared to the left ventricular diastolic pressure.

o **Treatment:**

- Pericardiectomy is the only definitive management of chronic constrictive pericarditis and effort should be made to remove as much of the pericardium as possible. Extensive penetration of the myocardium by fibrosis and calcification is associated with poor outcomes.
- Pericardiectomy is best performed through a median sternotomy approach with pump standby, reserving a thoracotomy approach for cases of suspected infection. The pericardium is removed to within 2 cm of the phrenic nerves on either side, or at least as far as exposure allows. Dissection of the aorta and pulmonary arteries should be performed first, followed by the left and then the right ventricle to avoid pulmonary edema.

- When the dissection plane between the thickened pericardium and the epicardium is difficult to achieve, the operation can be quite tedious. When dense calcific adhesions are present without a cleavage plane, the use of CPB may allow for a safer dissection, although bleeding may be increased by heparinization. It is frequently prudent to leave heavily calcified areas adherent to the heart to minimize bleeding and pericardial damage.
- Rarely, patients will develop epicardial constriction with a severe inflammatory response postoperatively, anecdotally noted in some patients with prior mediastinal radiation. This problem is approached using a "waffle" procedure, which entails multiple crisscrossing incisions in the scar tissue to optimize ventricular expansion and filling.
- The operative mortality for pericardiectomies is 5-10%. Factors that compromise the long-term results of pericardiectomy include higher NYHA class, radiation-induced constriction, higher PA pressures, worse LV systolic function, and the presence of hyponatremia or renal dysfunction.

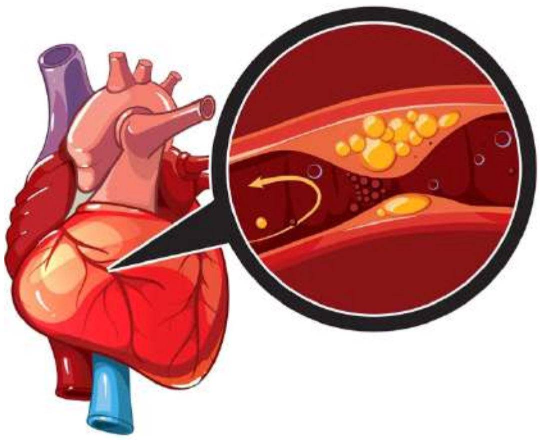


DAY 9 (12th of July 2024)

In the morning I had a chance to join Dr. Ruda Vega in a robotic surgery. He did LIMA harvesting with a Da-vinci robot and did the LIMA-LAD bypass by left mini-thoracatomy. In the afternoon Dr. Ruda Vega performed CABG x4. Lima to LAD, SVG to RCA, SVG to circumflex and marginal. His fellow let me assist him for the LIMA harvesting.

Coronary Artery Bypass Grafting (CABG) Indications

- **Indications for surgery in SIHD (stable ischemic heart disease)** –> The primary indication for surgical revascularization is to improve symptoms. PCI is applicable to many of these patients, but CABG must be considered for diabetic patients and those with high SYNTAX scores and when satisfactory PCI cannot be accomplished.



1. Class I indications
   1. ≥1 significant stenoses with unacceptable angina despite guideline-directed medical therapy (GDMT)
   2. Unprotected left main stenosis >50%
   3. Three-vessel disease with/without proximal LAD disease
   4. Two-vessel disease with proximal LAD disease
   5. Survivors of sudden death with presumed ischemic-mediated ventricular tachycardia (VT)
2. Class IIa indications
   1. ≥1 significant stenoses in patients who cannot implement GDMT
   2. Complex three-vessel disease (SYNTAX score >22) with/without proximal left anterior descending (LAD) artery stenosis
   3. Two-vessel disease without proximal LAD disease with a large area of ischemic myocardium
   4. One-vessel disease with proximal LAD disease (with a left internal thoracic artery [LITA] graft)
   5. Proximal LAD or multivessel disease with EF 35–50% if viable myocardium in the region of intended revascularization
3. Class IIb indications
   1. Redo CABG with ≥1 significant stenoses with ischemia and unacceptable angina despite GDMT.
   2. One, two or three-vessel disease except left main with EF <35%

- **Management strategies in acute coronary syndromes**

1. **Non-STEMI** patients or those with unstable angina without a troponin leak usually have the substrate for recurrent ischemia and infarction. They should be treated with aspirin (162–325 mg) and unfractionated or low-molecular-weight heparin (LMWH), as well as standard therapies (e.g. nitrates, β-blockers, statins, ACE inhibitors). A P2Y12 inhibitor, usually clopidogrel or ticagrelor, should be given in addition to aspirin to patients with non-STEMIs, but it is not necessarily indicated in patients with normal troponin levels.
   Initiation of dual antiplatelet therapy will provide a clinical benefit and will also provide adequate platelet inhibition for a PCI which is feasible in most patients to relieve ischemia and prevent infarction. In patients who are considered intermediate–high risk for a clinical event or exhibit a large thrombus burden, the addition of a glycoprotein (GP) IIb/IIIa inhibitor may be considered (class IIb indication). If PCI is not feasible or is unsuccessful, a CABG is indicated.

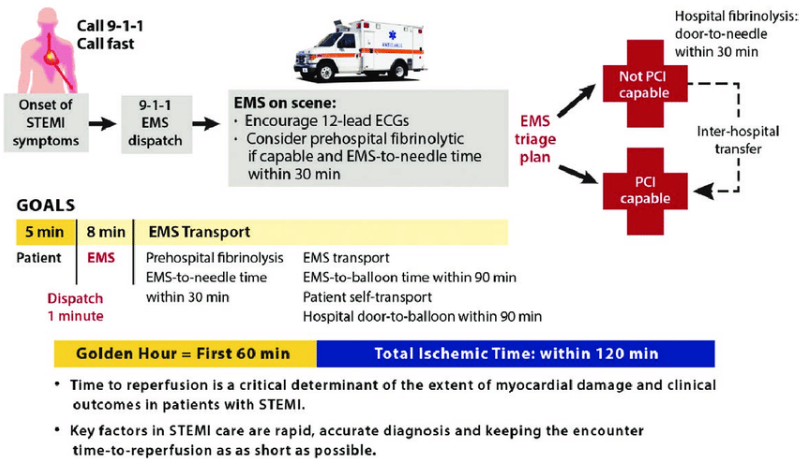
    a) Low-risk patients may stabilize on medical therapy and can undergo risk stratification by noninvasive testing to assess the extent of inducible ischemia (the "ischemia-guided strategy"). Various scoring systems (GRACE or TIMI score for UA/NSTEMI) can be used to quantitate the patient's short-term risk of an ischemic event. The GRACE score provides estimates of in-hospital and six- month mortality and the TIMI score provides the 14-day risk of mortality, new or recurrent MI, or severe recurrent ischemia requiring urgent revascularization.

    b) In patients at intermediate–high risk, an "early invasive strategy" is used, which triages the patient to early catheterization. Although this strategy is considered to lead to improved outcomes compared with the ischemia-guided approach, some studies show that 10-year outcomes are comparable. This approach provides an early definition of the patient's coronary anatomy and allows for early intervention to prevent myocardial damage. This strategy has been subdivided into immediate (<2 hours), early (<24 hours), or delayed (25–72 hours) catheterizations, depending on the patient's presentation. The immediate approach is applicable to patients with recurrent or refractory angina, ECG changes at rest, new-onset heart failure (HF), new-onset mitral regurgitation (MR), or hemodynamic instability. New ST depressions with rising troponins or a GRACE score >140 are an indication for an early approach, and patients with diabetes, chronic kidney disease, EF <40%, a GRACE score of 109–140, or a TIMI score ≥2 can have a delayed invasive approach.

    c) Since most patients are given a P2Y12 inhibitor upon hospital admission, when the extent of their coronary disease is not known, there will be patients undergoing catheterization in whom PCI is not feasible or in whom the benefits of CABG outweigh those of PCI (i.e. most diabetic patients with multivessel disease and patients with distal LM disease). An urgent CABG may then be recommended. A lower risk of renal dysfunction is noted for patients having on-pump CABG if surgery can be delayed for 24 hours after catheterization.

For patients requiring urgent, but not emergent, surgery who receive a P2Y12 inhibitor, surgery should be delayed at least 24 hours, if possible, and platelet aggregation testing obtained to elucidate whether the patient is sensitive or not to the P2Y12 inhibitor.28,29 If inhibition is <30%, surgery can usually be done safely without resorting to platelet transfusions to control mediastinal bleeding.

2. **ST elevation infarctions (STEMIs)** are usually associated with coronary occlusions and are preferentially treated by primary PCI, although thrombolytic therapy may be considered when PCI cannot be performed within a few hours. Clinical benefit is time-related ("time is myocardium"), and the best results are obtained with a "door to balloon" time of less than 90 minutes.
However, PCI should still be considered up to 12 hours after the onset of symptoms, at 12–24 hours if the patient has HF, persistent ischemic symptoms, or hemodynamic or electrical instability, or at any time if cardiogenic shock is present. Emerging data suggest that improved survival may be achieved using mechanical circulatory support (MCS), such as an Impella (Abiomed, Danvers, MA) device, prior to PCI. All patients presenting with a STEMI and with no contraindications to antiplatelet treatment should be given one dose of aspirin 325 mg, a load of either clopidogrel 600 mg or ticagrelor 180 mg, and either unfractionated heparin or bivalirudin upon presentation to the emergency room, if not sooner (i.e. in the ambulance).



a. Suppose PCI of the culprit vessel can be accomplished in a patient with multivessel disease. In that case, it remains controversial as to whether stenting of other non-culprit stenotic vessels should be performed at the same time, even in patients with cardiogenic shock. However, some observational studies do suggest a benefit. However, if it is concluded that the other vessels would be better revascularized by surgery, the patient may be referred for CABG having received a P2Y12 inhibitor to prevent stent thrombosis. Once the culprit vessel has been opened, surgery is rarely required emergently. Thus, the oral P2Y12 inhibitor may be stopped and the patient is given either a short-acting P2Y12 inhibitor (IV cangrelor) or a GP IIb/IIIa inhibitor as a bridge to surgery.

b. If PCI cannot be accomplished or is considered inadvisable due to extensive LM or multivessel disease, emergency surgery should be performed.
Early surgical studies showed little myocardial salvage if CABG was not performed within six hours, with a significant increase in mortality for surgery performed between 7 and 24 hours, and then lower mortality after.

c. If PCI cannot be performed or has failed, the ACC guidelines recommend emergency surgery for the following:

Class I:

- ➔ Persistent ischemia or hemodynamic instability refractory to nonsurgical therapy (it is not stated if that includes an intra-aortic balloon pump [IABP])
- ➔ Cardiogenic shock irrespective of the time from MI to the onset of shock and the time from MI to CABG
- ➔ Mechanical complications of MI
- ➔ Life-threatening ventricular arrhythmias with LM or three-vessel disease

Class IIb

- ➔ Multivessel disease with recurrent angina or MI within 48 hours of presentation
- ➔ Patients > age 75 with ST elevation or left bundle branch block (LBBB) regardless of time since presentation if in cardiogenic shock

WEEK 3

DAY 10 (15th of July 2024)

Today I joined a rare procedure called Dor procedure. It takes its name from Dr. Dor who performed this surgery for the first time. This procedure is used to restore ventricular shape, increase ejection fraction, decrease the LVESVI and allow complete coronary revascularization.

Dor Procedure

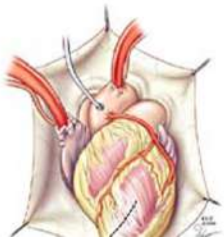
- Certain patients who present following a transmural anterior wall myocardial infarct with an akinetic or dyskinetic wall segment, have been shown to benefit from endoventricular circular patch plasty as described by Dor.
- Reconstructive surgery of the altered left ventricular topography results in a permanent improvement in the ventricular wall function, including non-ischemic zones remote from the anterior wall left ventricular aneurysm.

- **Operative Steps**

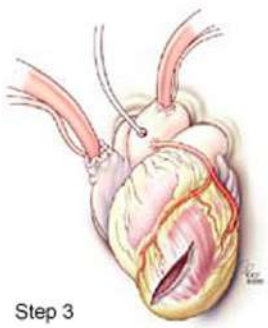
  1. The patient is anesthetized in the supine position and intubated with a single lumen endotracheal tube.
  2. The patient should be prepped and draped for full sternotomy. A transesophageal echography probe is passed to assess left ventricle function, evaluate the aneurysm, assess for the presence of intracavitary thrombus, and rule out associated valve disease.

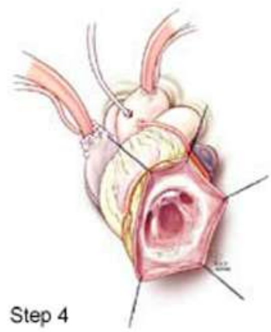
It is also useful to assess the clearance of intracardiac air at the completion of the procedure. Approximate 90% of the patients undergo concomitant coronary artery bypass grafting and 45% undergo Mitral Valve repair.

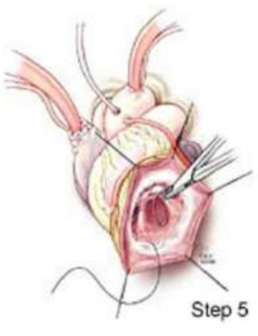
3. A median sternotomy is performed and the heart is exposed. After the patient is heparinized, an aortic cannula is inserted in the distal ascending aorta, and a double-stage venous cannula is placed into the right atrium. The patient is placed on cardiopulmonary bypass and maintained warm. If coronary artery bypass is to be performed, a retrograde cardioplegia cannula is inserted through the right atrium into the coronary sinus. The aorta is cross-clamped and antegrade cold blood cardioplegia is given. This is followed by cold-blood retrograde cardioplegia, which is repeated every 15 minutes.

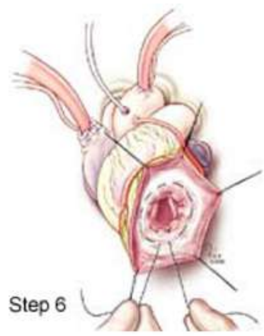


4. After the associated pathologies are treated, a dose of warm retrograde cardioplegia is given and the aorta is unclamped. With the heart contracting, the aneurysm (which most of the time is located in the apical anterior wall) is examined. If clot was identified in the aneurysm on TEE this aneurysm is opened and the clot is removed prior to removing the clamp. Z4The aneurysm is entered using a 15-blade knife. Make sure that the entrance point is at least 1.5 to 2.0 cm from the LAD, which will facilitate subsequent closure.





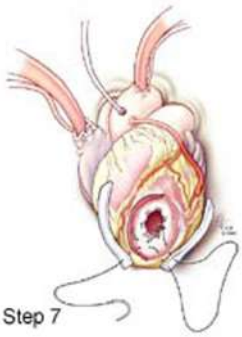




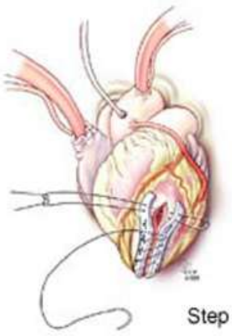
5. The cavity of the left ventricle is carefully examined and any intracavitary thrombus extracted. Visual inspection and palpation identify the edge between the aneurysm al scar tissue and viable contracting myocardial.

6. After the extension of the endocardial scarring is determined, a purse-string suture of 2-0 polypropylene is placed around the entire circumference of the base of the aneurysm at the junction of the scar and normal myocardium. The purse-string suture is then tied down snuggly from the inside restoring the ventricular cavity geometry.The degree of tightening of this suture will determine the size of the remaining opening of the ventricle.

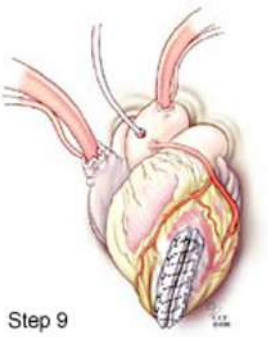
7. If the remaining opening of the ventricle is larger than 3 centimeters, a second purse-string suture of 2-0 polypropelene can be placed 4 mm distal to the first one. With the use of this second purse-string we have been successful decreasing the size of the ventricular opening to less than 3 cm and avoid the use of patch material to close the ventricle
8. If the ventricular opening is larger than 3 cm despite the second purse-string, it can be closed using a hemashield patch, as described by Dor. The endocardial patch is secured in place with interrupted vertical mattress sutures of 3-0 polypropylene placed through the edges of the patch and then transmurally from the endocardium to the epicardium at the level of the purse-string suture and tied over a felt pledget.
9. The edges of the ventricular free wall are then approximated using a interrupted mattress sutures of 3-0 polypropylene tied over felt strip and reinforced with a continuous running suture of 3-0 polypropylene.



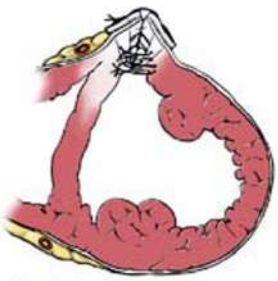
Step 7



Step 8



Step 9



Step 10

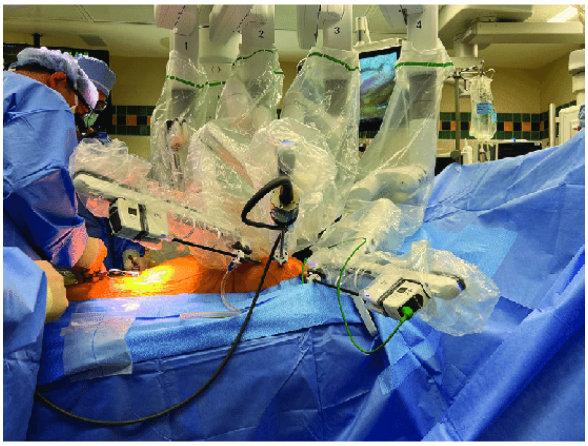
10. Hemostasis is ascertained and patient is slowly weaned from cardiopulmonary bypass, after transesophageal echocardiogram confirms adequate deairing of the left ventricle. Transesophageal echocardiogram is repeated, at this time, to reevaluate the left ventricle contractility and the mitral valve function.
11. Anticoagulation is reversed and the aorta and right atrium are decannulated. Atrial and ventricular pacing wires are inserted and secured. Mediastinal drainage tubes are placed. The sternotomy is approximated with stainless steel wire. The pectoralis fascia, subcutaneous tissue and skin are closed with absorbable suture.
12. No anticoagulation is necessary postop, unless required for associated pathologies.

- Intra-operative transesophageal echocardiography is mandatory to evaluate the contractility of the left ventricle, rule out mitral or aortic valve pathology, and the presence of intracavitary thrombus or intracardiac shunts.
- Direct palpation of the left ventriclar wall with the heart beating, after the cross clamp has been removed, greatly assists in the differentiation of non-contractile scar tissue from viable myocardium.

DAY 11 (16th of July 2024)

Today, I had a chance to join Dr. Ruda Vega in a robotic surgery. He did LIMA harvesting with a Da-vinci robot and did the LIMA-LAD bypass by left mini-thoracatomy.

Minimally Invasive/Robotic Surgery



- Robotic or totally endoscopic coronary artery bypass (TECAB) can be used to minimize the extent of the surgical incisions and reduce trauma to the patient.
- Robotics can be used for both ITA takedown and grafting to selected vessels through small ports. These procedures can be done without CPB or using CPB with femoral cannulation. Generally, TECAB is used for limited grafting, but wider applicability is certainly feasible.
- The patient is positioned with the left side slightly elevated. The left arm may be abducted to improve exposure, but excessive abduction can cause brachial plexus stretch. The limited exposure to the heart and avoidance of CPB for off-pump procedures mandate adequate monitoring for ischemia, comparable to that noted for OPCABs.
- For robotic cases, the lateral ECG leads must be placed posteriorly and laterally to avoid the port access sites. Defibrillator pads must be placed out of the way of the ports as well, which may produce a suboptimal axis for defibrillation in the event of ventricular fibrillation.
- For off-pump procedures, a single radial arterial line is placed for monitoring. If the procedure will be done on CPB using cardioplegic arrest, two arterial lines should be placed if an endoballoon is used for aortic cross-clamping. TEE is helpful in off-pump procedures by identifying RWM abnormalities during con- struction of anastomoses or afterwards.
- Procedures performed through small incisions limit surgical exposure to the heart.
- Since all minimally invasive valve procedures and some totally endoscopic/robotic coronary bypass grafting are performed on-pump, CPB-related problems, whether pulmonary, cardiac, or renal in nature, are similar to those noted above for specific valve pathology. However, there are a few specific issues that may arise in these patients.
- Pain control is essential following ministernotomy and rib-spreading procedures. Similar to MIDCABs, use of epidural analgesia or intercostal blocks can optimize patient comfort and pulmonary status.
- Access to the RV is limited, making placement of pacemaker wires somewhat dif ficult. The ability to pace the heart using pacing pads (which are fairly uncomfort able) or using a ventricular pacing wire placed through a Swan-Ganz Paceport catheter is useful.

- Placement of chest tubes may not be ideal, because of exposure limitations. Usually one pleural and one anterior mediastinal tube are placed, but they may not provide ideal drainage. It is essential to be alert to the potential for undetected accumulation of blood in the pleural space or for the development of tamponade when the patient is hemodynamically unstable.
- Although some minimally invasive incisions allow for central aortic and venous cannulation, all robotic cases and other minimally invasive cases with limited exposure require alternative cannulation sites – usually the femoral artery and/or vein.
- The presence of aortoiliac disease, tortuosity with calcification, very small femoral arteries, or thoracic or abdominal aneurysmal disease generally contrain dicates femoral cannulation, so axillary or central cannulation must be used. Insertion of a femoral cannula is accomplished by direct cutdown or percutaneous placement. Following decannulation, the artery is repaired under direct vision unless placed percutaneously. The potential for hemorrhage, femoral artery injury, development of an AV fistula or false aneurysm, focal thrombosis, or distal athero embolism exists. It is absolutely essential that distal perfusion be assessed at the conclusion of surgery by pulse or Doppler examination.
- Because these operations can be tedious, especially in the early part of the learning curve, the bypass run may be quite long, often over four hours. This could potentially lead to a lower-extremity compartment syndrome.
- Since the anesthetized patient cannot complain of pain or sensory changes or exhibit motor function, assessment of calf size and tenseness at the conclusion of surgery and in the ICU on a frequent basis is essential to recognize the very early stages of a compartment syndrome. Early fasciotomy can salvage muscle and limb function; delayed fasci otomy may be the first step towards an amputation
- Minimally invasive direct coronary artery bypass grafting (MIDCAB) entails per formance of an anastomosis of the left internal thoracic artery (LITA) to the left anterior descending artery (LAD). This is performed through a left thoracotomy incision using one-lung anesthesia.
- Patients are generally extubated in the OR or soon after arrival in the ICU. Epidural or intrathecal morphine analgesia (Duramorph) is helpful in reducing splinting and improving respiratory efforts in patients who might otherwise have significant chest wall pain from rib retraction, resection, or fracture. A local infusion of bupivacaine into the wound is also helpful and may provide superior pain relief to the use of PCA alone.
- No pacing wires are placed, so a heart rate in the 60–70 bpm range is acceptable. Ventricular pacing wires placed through a Swan-Ganz Paceport catheter can be used for bradycardia, but generally they do not provide optimal hemodynamics. External pacing may be used, if necessary.
- A postoperative ECG must be obtained and carefully reviewed for any evidence of ischemia, because anastomotic problems are more common when surgery is performed on a beating, rather than an arrested, heart.
- Intrapericardial or intrapleural bleeding may originate from the chest wall, the anastomotic site, or side branches of the ITA. Blood will more readily accumu late in the pleural space during spontaneous ventilation. The possibility of bleed ing should be monitored by observing chest tube drainage and a postoperative chest x-ray.

DAY 12 (17th of July 2024)

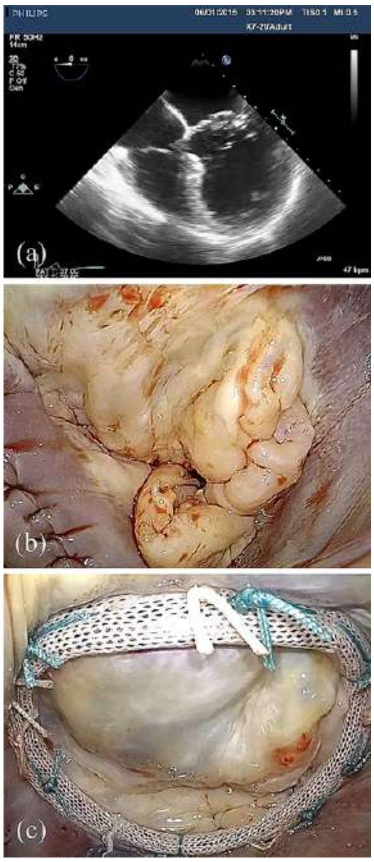
Today I joined a case with Dr. Pelletier, it was a mini-thoracotomy mitral valve repair vs replacement. The interesting thing about this case is that there was an A1 prolapse (which is rare) and the patient had barlow's valve. We looked at the intraoperative TEE images with a pre-med student and we found it quiet extraordinary. Dr. Pelletier then decided to change the valve because it was unrepairable.

Barlow's Valve

The syndrome of mid-systolic click accompanying a systolic murmur was first described in the late 1800s. Still, it was in the early 1960s that Barlow and colleagues demonstrated its association with mitral regurgitation. They identified the mechanism of the regurgitation as posterior leaflet prolapse due to excess leaflet motion, coining the phrase "mitral valve prolapse". Carpentier and co-workers later characterized the surgical lesions resulting from the myxoid degeneration present in Barlow's disease, which included leaflet thickening, large redundant leaflets, chordal elongation or rupture, and annular dilatation. As the myxoid degenerative process often affects the entire valve, patients with Barlow's disease generally have complex valve pathology and dysfunction, which is most often multisegmental (i.e. involves more than one segment of the posterior or anterior leaflet). Fibroelastic deficiency and Barlow's disease are the two most common etiologies of degenerative mitral valve (MV) disease, often leading to significant mitral regurgitation (MR).

Clinical Presentation

Patients with Barlow's mitral valve disease are generally adults around the age of 50 years who have known for a long time, often decades, that they "have a murmur". Often asymptomatic, patients may have been followed by an internist for years, and referral to a cardiologist and subsequently to a cardiac surgeon is usually triggered by the development of symptoms or signs such as atrial fibrillation, shortness of breath and fatigue, or echocardiographic documentation of ventricular or atrial enlargement, or a decline in ventricular function, often accompanied by varying degrees of pulmonary hypertension. Physical examination most often reveals the presence of a mid-systolic click and a mid to late systolic murmur, which reflects the timing of prolapse in the setting of excess tissue and chordal elongation without chordal rupture (i.e. flail leaflet).



Echocardiographic Findings

Echocardiography is a sensitive tool in the differentiation of degenerative mitral valve disease. A striking feature of the patient with Barlow's disease is the size of the valve apparatus - the leaflets are usually thick, bulky, elongated, and distended; the chords thickened and elongated, often mesh-like in nature; and the annulus dilated and enlarged, often greater than 36mm in the inter-commissural distance

The prolapse is often multisegmental and involves both leaflets in up to 40% of patients. The insertion of the posterior leaflet is usually displaced toward the left atrium away from its normal insertion in the atrioventricular groove, creating a cul-de-sac at the base of the leaflet. The bodies of distended leaflet segments often billow above the plane of the annulus, and the margin of the leaflet segments prolapse in mid-systole in the setting of chordal elongation, or early systole if chordal rupture has occurred. Calcification of the annulus and papillary muscles may be present. Real time three-dimensional echocardiography allows additional clarity of the segmental nature of the billowing, as well as prolapse, in Barlow's disease and may play a critical role in the preoperative work up of these patients in the future.

Surgical Considerations

The complexity of surgical lesions in Barlow's mitral valve disease is consistent with the echocardiographic findings. Lesions include excessively thick and billowing leaflet segments, chordal elongation and chordal rupture, calcification of the papillary muscles or annulus with chordae restriction, and severe annular dilatation with giant valve size. It is important that the cardiologist as well as the surgeon has an appreciation for these lesions, as the complexity of techniques required to achieve a successful repair then becomes obvious in this subset of degenerative mitral-disease patients. Dealing with excess tissue height is an important consideration to reduce the likelihood of postoperative systolic anterior motion. Repair of Barlow's valves is thus more complicated and, in our experience, often requires multiple different techniques and 2-3 hours to remove all of the diseased tissue and reconstruct the leaflets to a normal configuration. To achieve a Barlow's repair, the surgeon therefore needs to be well-versed with various advanced mitral repair techniques, such as extensive leaflet resection, sliding leaflet plasty, chordal transfer, neochordoplasty, commissuroplasty, annular decalcification and use of large annuloplasty rings. Patients with advanced forms of Barlow's disease will therefore likely have a high probability of successful valve repair only if done in reference centers by mitral subspecialists.

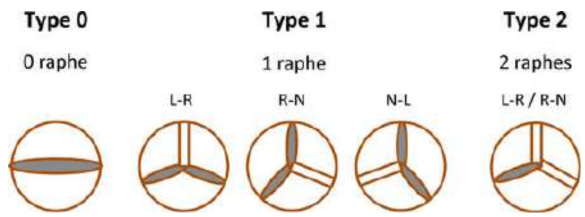
	Likelihood of successful repair	
	Experienced cardiac surgeon	Reference mitral valve surgeon
FED: posterior leaflet prolapse	Almost certain	Certain
FED: anterior leaflet prolapse	Possible	Certain
Barlow's disease: posterior leaflet	Possible	Certain
Barlow's disease: anterior or bi-leaflet	Unlikely	Almost certain

FED, fibroelastic deficiency.

Minimally invasive (MIS) MV surgery has proven to be feasible and technically acceptable for a wide range of pathologies. Mounting data in the literature supports the hypothesis that MIS can provide at least equivalent results for surgical correction of MR with several associated clinical benefits. Although MIS should be predominantly reserved for non-complex pathologies (e.g., FED, isolated P2 prolapse) during the initial part of the surgeon's learning curve, it has also been demonstrated that such techniques can be safely and effectively utilized for complex mitral pathologies (e.g., bileaflet prolapse and Barlow's disease) in high volume centers.

DAY 13 (18th of July 2024)

Today, I joined Dr. Abdel Halim and Doctor Baeza. Patient had a history of severe AS, mild AR, HTN, HLD, hyperglycemia with normal LVEF. Ross procedure was planned for this patient but once they saw the valve, they realized that it was type 0 bicuspid aortic valve (also called as symmetrical) which is not suitable for the new pulmonary valve. So Ross was not performed, instead it turned into an aortic valve replacement surgery. Dr. Halim mentioned that the aortic root was also dilated so they switched it with a graft.



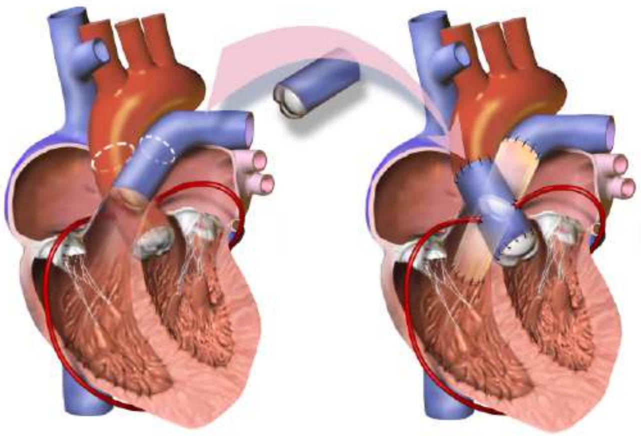
Ross Procedure

The Ross procedure, also known as the switch procedure or pulmonary autograft procedure, is a cardiac surgery in which a diseased aortic valve is replaced with the patient's own pulmonary valve. This is followed by the replacement of the pulmonary valve with a pulmonary allograft. The Ross procedure was first developed in the late 1960s and has been performed many times since. It is the only operation that allows for an aortic valve replacement with a living valve substitute. This activity describes the indications, contraindications, and steps involved in the Ross procedure and highlights the role of the interprofessional team in the management of patients with aortic valve disease.

Introduction

The Ross procedure, also known as the switch procedure, is a cardiac surgery procedure in which the diseased aortic valve is replaced with the patient's own pulmonary valve, followed by the replacement of the pulmonary valve with a pulmonary homograft. In some children and infants, sometimes and aortic valve replacement is necessary for a variety of reasons. However, inserting a prosthetic valve is not a good option; firstly there are no small-sized aortic valves available and secondly, since the child will grow in size, the prosthetic valve will remain the same size and lead to symptoms of left ventricular outflow tract obstruction. In addition, some people do not want to take oral anticoagulant medications for life and hence a Ross procedure would be ideal for them. Unlike a prosthetic valve, the ross procedure has excellent hemodynamics and the risk of embolic complications is almost zero. Finally, as the child grows, so does the valve. Unfortunately, it is now realized that the Ross procedure also has limitations; the pulmonary homograft will develop regurgitation or stenosis after 15-20 years, necessitating another procedure.

The Ross procedure was first developed in the late 1960s and has been performed many times since then. It remains to be the only operation that allows for an aortic valve replacement with a living valve substitute.



Over the years, the original procedure has been gradually modified to perfect the surgical outcome, but the main principles outlining the procedure remain.
This chapter will discuss in detail the anatomy of the aortic valve, indications, contraindications, equipment, personnel, preparation, technique, complications, and clinical significance of the Ross procedure.

Indications

Indications for the Ross procedure include

- Aortic valve disease in children with congenital aortic stenosis (most common indication)
- Females of childbearing age wanting to bear children in the future with bicuspid aortic valve and small aortic annulus
- Some variations of left ventricular outflow obstructive disease
- Native or prosthetic valve endocarditis depending on the extent of disease
- Some forms of adult aortic regurgitation with a dilated aorta
- Severe forms of aortic valve disease not amenable to repair

Contraindications

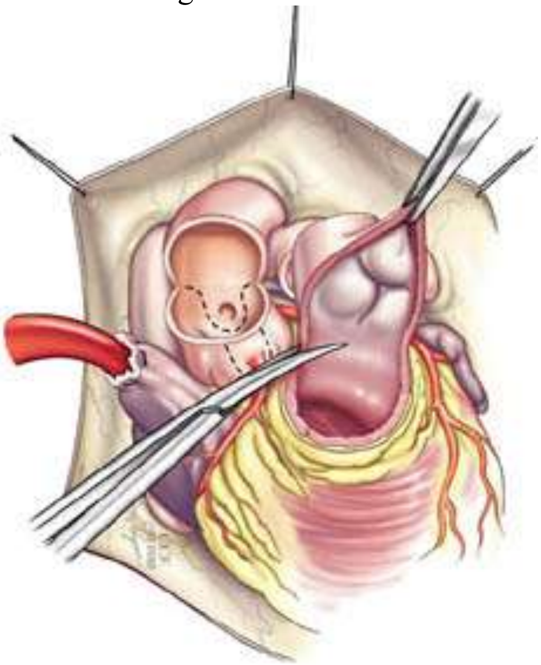
Absolute contraindications

- Marfan syndrome
- Pulmonary valve disease
- Immune disorders like lupus
- Advanced three-vessel coronary artery disease
- Significant mitral valve disease

Technique or Treatment

- Following a median sternotomy, the Ross procedure begins with standard exposure of the heart and the aorta followed by establishing cardioplegia and initiation of cardiopulmonary bypass. The ascending aorta is opened transversely about a centimeter above the origin of the right coronary artery (RCA). The aorta is opened and the aortic valve is inspected. In some cases, the valve may be repaired. If repair is not possible, then the pulmonary artery is opened and the pulmonary valve is inspected to ensure that it has normal anatomy. If the decision is made to proceed with the Ross procedure, the aorta is separated from the aorta, the diseased aortic valve is excised and the coronary buttons are prepared. Next, the pulmonary valve is excised.

- If no abnormalities are present, the main pulmonary artery (PA) is opened transversely proximal to the bifurcation. The pulmonary valve (PV) is then inspected for anomalies. Again if no abnormalities exist, then the valve replacement is performed using the full root approach. The full root approach is most commonly used about 90% of the time because it has the lowest risk of pulmonary autograft failure. In rare circumstances, depending on the anatomy, another approach may be a better choice, such as the sub-coronary, sub-coronary with retained noncoronary sinus, or cylinder approaches.
- The full root approach is begun by moving the root out of the surgical plane and pushed upwards. The posterior PA root is then cut to the muscle to visualize the right ventricular outflow tract (RVOT) through the incision.
- Next, the PA is separated from the aorta, and a clamp is then used to designate the most proximal area to the pulmonary valve. It is vital that the surgeon be aware of the left anterior descending coronary artery and the first septal while dissecting on the lateral side.
- In the next step, an opening into the RVOT is created followed by dividing the anterior right ventricle and scoring the posterior muscle of the right ventricle partially. Following this, the pulmonary artery root is excised and separated. Next, removal of the aortic valve and root occurs after carefully cutting out the ostia with buttons from the native aorta.
- Once the pulmonary valve is removed, it is sized and prepared for implantation into the aortic root.
- Now the pulmonic autograft is anastomosed to the LVOT followed by reimplantation of the right and the left coronary arteries on to the autograft, followed by proximal anastomosis of the pulmonic autograft, and hemostasis is secured.
- A cryopreserved pulmonary homograft is then trimmed as needed and implanted into the pulmonary root. After weaning from cardiopulmonary bypass, a transesophageal echocardiogram is done to assess the function of the autograft and the homograft.



- Prior to discharge, an echocardiogram is repeated to ensure that both the aortic and pulmonary valves are functioning normally. Patients are then examined every 4-6 weeks with echos. It is important to cover patients with antibiotics prior to any procedure.

Clinical Significance

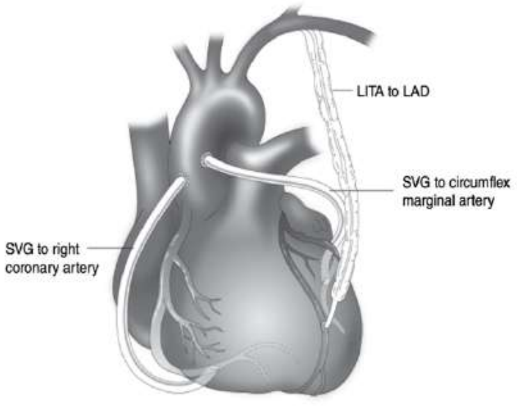
Multiple studies have shown that there is a durable, long-term clinical success from this procedure with an extremely low mortality rate. Because this procedure uses biological valves, it obviates the need for oral anticoagulation which would have otherwise been necessary for this particular group of patients because they would have needed mechanical valves. The Ross procedure also eliminates the need for aortic valve replacement for up to as much as 20 years. This is probably due to two factors. One being that the autographed pulmonary valve in the place of the aortic valve has the ability to grow as the patient grows and the second being that there are lower pressures in the right side of heart creating for less stress on the pulmonary valve replacement and subsequently this leads to a reduced failure rate. Overall, this procedure is an excellent option for children and youth to improve survival. It remains to be the only operation that allows for an aortic valve replacement with a living valve substitute.

DAY 14 (19th of July 2024)

Today I joined a case with both Dr. Ruda Vega and Dr. Rushing. It was a on pump CABG. Patient's history was significant for CAD, HFrEF 30%, NSTEMI, T2DM, HTN, CKD (Cr of 2.49), HLD and moderate MR. They used sketelonized method for ITA harvesting from subclavian to xiphoid process. After the harvesting, they injected papaverin which is a vasodilator for better blood flow.

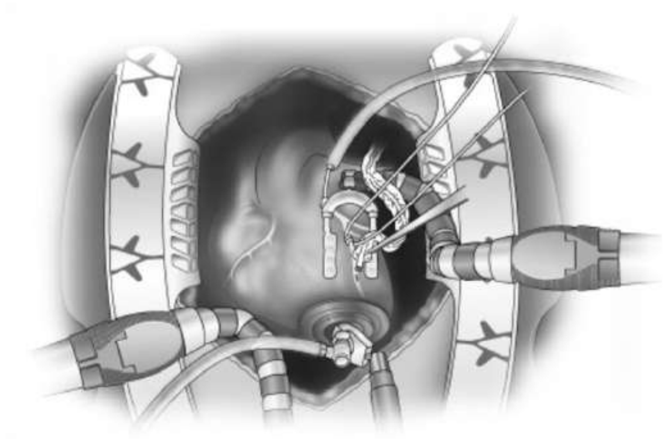
CABG Surgical Techniques

1. **Traditional coronary artery bypass grafting** is performed through a median sternotomy incision with the use of CPB. Myocardial preservation is provided by cardioplegic arrest. The procedure involves bypassing the coronary blockages with a variety of conduits. The left internal thoracic (or mammary) artery (ITA) is usually used as a pedicled graft to the LAD and is supplemented by either a second ITA graft or radial artery graft to the left system and saphenous vein grafts interposed between the aorta and the coronary arteries.
   a. The saphenous vein should be harvested endoscopically to minimize patient discomfort, reduce the incidence of leg edema and wound healing problems, and optimize cosmesis. There are some concerns that endoscopic harvesting could produce endothelial damage that might compromise long-term patency and reduce long-term survival. Still, with more experience, this is not an issue.
   b. Additional arterial conduits (bilateral ITAs, radial artery) can be recommended to improve event-free survival. The radial artery can be harvested endoscopically using a tourniquet to minimize bleeding during the harvest with placement of a drain afterward to prevent blood accumulation within the tract.



With radial artery grafting, the use of a topical vasodilator, such as a combination of verapamil and nitroglycerin, is useful in minimizing spasms. The STS guidelines suggest the use of a systemic vasodilator during surgery, and IV diltiazem 0.1 mg/kg/h (usually 5–10 mg/h) or IV nitroglycerin 10–20 μg/min (0.1–0.2 μg/kg/min) are commonly used. This is continued in the intensive care unit and then converted to either amlodipine 5 mg po qd or Imdur 20 mg po qd for several months. The purported benefit of such pharmacologic management to prevent spasms has been universally accepted, although not rigorously studied, and routine use may not be indicated.

2. Concerns about the adverse effects of CPB spurred the development of **"off-pump" coronary surgery (OPCAB)**, during which complete revascularization should be achieved with the avoidance of CPB. Deep pericardial sutures and various retraction devices are used to position the heart for grafting without hemodynamic compromise. A stabilizing platform minimizes movement at the site of the arteriotomy. Intracoronary or aortocoronary shunting can minimize ischemia after an arteriotomy is performed.



a) Conversion to on-pump surgery may be necessary in the following circumstances:
   i. Coronary arteries are very small, severely diseased, or intramyocardial.
   ii. LV function is very poor, or there is severe cardiomegaly or hypertrophy that precludes adequate cardiac translocation without hemodynamic compromise or arrhythmias.
   iii. The heart is extremely small and vertical in orientation.
   iv. Uncontrollable ischemia or arrhythmias develop with vessel occlusion that persists despite distal shunting.
   v. Intractable bleeding occurs that cannot be controlled with vessel loops or an intracoronary shunt.

b) OPCABs reduce transfusion requirements and the incidence of AF, but whether there is a reduction in the risk of stroke and renal dysfunction remains controversial.76 OPCABs generally result in fewer grafts being placed, resulting in more incomplete revascularization and more repeat revascularization. Numerous long-term follow-up studies have shown inferior survival to on-pump surgery. Enthusiasm for this technique is modest, and it is estimated that less than 20% of CABGs are performed off-pump.

One randomized trial did show better outcomes with OPCABs when performed for a STEMI within six hours from the onset of symptoms or for patients in cardiogenic shock,80 but most surgeons reserve its use for patients with limited disease. Its major advantage may be in the very high-risk patients with multiple comorbidities in whom it is critical to avoid CPB.

c) In patients with severe ventricular dysfunction, the heart will not tolerate the manipulation required during off-pump surgery. In this circumstance, right ventricular (RV) assist devices can be used to improve hemodynamics. Alternatively, surgery can be done on-pump on an empty beating heart to avoid the period of cardioplegic arrest. This technique may be beneficial in patients with ascending aortic disease that prevents safe aortic cross-clamping but does allow for safe cannulation and use of an aortic punch, such as the Heartstring proximal seal system (MAQUET Cardiovascular), to perform the proximal anastomoses.

3. **Minimally invasive direct coronary artery bypass (MIDCAB)** involves bypassing the LAD with the LITA without the use of CPB via a short left anterior thoracotomy incision. Bilateral ITAs can be harvested under direct vision and an additional incision is made in the right chest to bypass the right coronary artery. Combining a LITA to the LAD with stenting of other vessels ("hybrid" procedure) has also been described. A meta-analysis of the MIDCAB procedure found a lower risk of repeat revascularization compared with PCI of the LAD.
4. **Robotic or endoscopic coronary artery bypass (TECAB)** can be used to minimize the extent of surgical incisions and reduce trauma to the patient. Robotics can be used for both ITA takedown and grafting to selected vessels through small ports. These procedures can be done without CPB or using CPB with femoral cannulation. Generally, TECAB is used for limited grafting, but wider applicability is certainly feasible.
5. **Transmyocardial revascularization (TMR)** is a technique in which laser channels are drilled in the heart with CO2 or holmium-YAG lasers to improve myocardial perfusion. Although the channels occlude within a few days, the inflammatory reaction created induces neoangiogenesis that may be associated with the upregulation of various growth factors, such as vascular endothelial growth factor. This procedure is most commonly used as an adjunct to CABG in viable regions of the heart where bypass grafts cannot be placed. It can also be used as a sole procedure performed through a left thoracotomy or thoracoscopically for patients with inoperable CAD.

WEEK 4

DAY 15 (22nd of July 2024)

Today, I joined Dr. Halim for his Aortic valve replacement case. The patient had a history of aortic valve regurgitation, prior aortic valve replacement, HTN and HLD. Dr. Halim decided to replace it again according to ECHO images and explained me the methods.

Aortic Regurgitation Surgical Treatment Options

- AVR has traditionally been the procedure of choice for adults with AR. This may involve use of a tissue or mechanical valve, the Ross procedure, or a cryopreserved homograft. Studies are underway to determine the feasibility of TAVR for pure AR.
- Aortic valve repair, involving resection of portions of the valve leaflets and re-approximation to improve leaflet coaptation (especially for bicuspid valves), often with a suture annuloplasty, has been performed successfully. This is valuable in the younger patients in whom any valve-sparing procedure is preferable to valve replacement.
- A valved conduit (Bentall procedure) is placed if an ascending aortic aneurysm ("annulo-aortic ectasia") is also present. In younger patients, manufactured mechanical valved conduits are preferable, but if there is a strong indication for avoiding anticoagulation, a "bio-root" created by sewing a tissue valve into a graft can easily be accomplished. Alternatively, a Medtronic Freestyle stentless valve can be placed with distal graft extension to replace an aortic aneurysm.
- Aortic valve-sparing root replacement is feasible in some patients with significant AR if adequate remodeling of the root can be accomplished, and it can be used successfully even in patients with bicuspid valves or Marfan syndrome. The aorta is resected, sparing the commissural pillars. A graft is then sewn at the sub-annular level, the aortic valve is resuspended within the graft, and the aortic remnants are sewn to the graft. Coronary ostial buttons are then sewn to the graft.

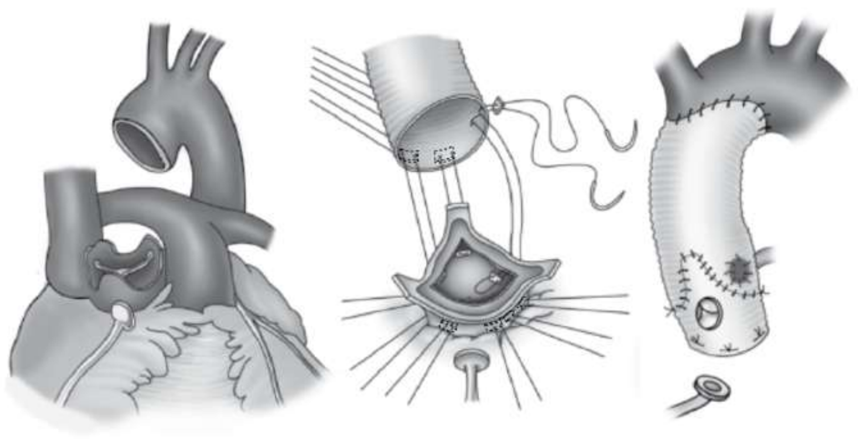
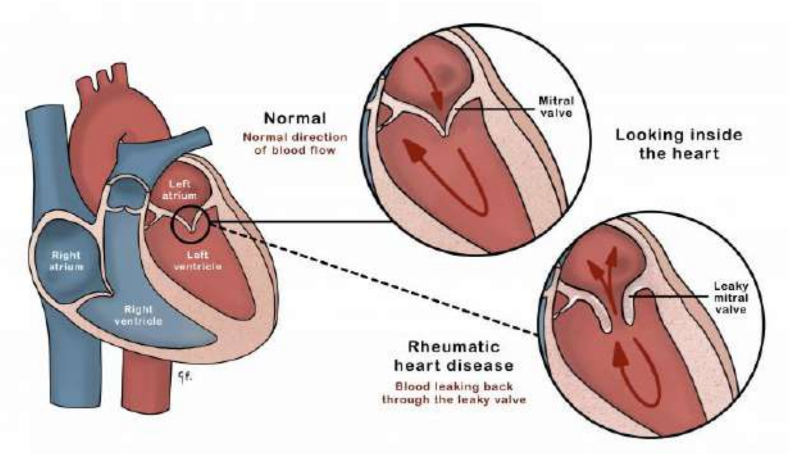


Figure 1.14 • Aortic valve-sparing root replacement. (A) The aortic root is resected, sparing the

DAY 16 (23rd of July 2024)

Today, I had a chance to join Dr. Sabik, at a really interesting case. Patient was a 69 year old female with a medical history of HTN, HLP, GERD and severe mitral regurgitation. Since her valve was very hard to repair because of the etiology, Dr. Sabik decided to use the pericardial patch technique.

Bileaflet Pericardial Patch Repair for Rheumatic Mitral Valve Disease



Surgical repair in rheumatic mitral valve disease is technically challenging as the disease affects both valvular and subvalvular structures. Due to the resultant shortage of pliable valve tissue, pericardial patch techniques are progressively used to restore normal valve function. This makes mitral valve repair possible even in the most severe forms of rheumatic mitral valve disease.

Surgical mitral valve repair is the treatment of choice in organic mitral valve disease. However, in the setting of rheumatic mitral valve disease, valve repair remains controversial. Rheumatic mitral valve disease is characterized by leaflet fibrosis and calcification, often resulting in a shortage of pliable leaflet tissue needed to secure a durable valve repair. As disease progression often causes restenosis and insufficiency, primary mitral valve replacement remains commonly performed. Alternatively, pericardial patch techniques can be used to restore normal leaflet pliability and mobility.

Surgical Technique

1. Transthoracic echocardiography demonstrated mild to moderate mitral regurgitation and severe mitral stenosis Left ventricular function was normal. Valve evaluation demonstrated typical features of rheumatic mitral valve disease: (recurrent) commissural fusion, mitral valve leaflet fibrosis, and calcification, and fusion and fibrosis of the subvalvular apparatus and the ventricular surface of the mitral valve leaflets. Taking all these aspects into consideration, the patient was accepted for surgical mitral valve repair.

2. The procedure was performed through a median sternotomy and myocardial protection was achieved by antegrade warm blood cardioplegia. Surgical analysis revealed restriction of the P1-P2 segments with thickened, fibrosed and fused chordae tendineae. Furthermore, calcification of the P2 and severe fibrosation of the A3 segment were observed. Extensive, recurrent fusion of the posteromedial commissure was also present. In order to restore normal leaflet motion, secure sufficient area of leaflet coaptation, and ensure a durable repair, all these problems needed to be addressed.

3. Restriction of the P1-P2 segments was addressed by resecting the fibrotic and shortened primary chordae of these segments. The corresponding papillary muscle was further mobilized to relieve residual leaflet restriction.

4. Severe commissural fusion was seen at the posteromedial commissure. To restore sufficient mitral valve area, the commissure was incised several millimeters from the annulus, extending towards the mitral valve orifice. No commissural fusion of the anterolateral commissure was present.

5. Severe fibrosation of the A3 segment was readily identified during valve analysis. The fibrotic leaflet tissue needed to be resected and replaced to restore normal leaflet pliability and motion. First, the fibrotic tissue was resected. Then leaflet augmentation with a decellularized pericardial patch (CardioCel, Admedus Regen Pty Ltd., Perth, WA, Australia) was performed. The pericardial patch was implanted with a running 5-0 monofilament polypropylene suture. Due to the lack of support at the free edge of the P3 and A3 segments, 2 pairs of polytetrafluoroethylene neochords were implanted. Each end of the neochord was passed through the leaflet (2-3 millimeters from the free edge) twice. The length of each end was adjusted to bring the level of the leaflet-free edge to the level of adjacent segments. Final corrections were made during the water test and the neochords were tied thereafter.

6. The severely fibrotic and calcific degenerated P2 segment – including the subvalvular apparatus – was first resected, all the way up to the mitral valve annulus. A second CardioCel pericardial patch was used to restore leaflet continuity, again using a running single 5–0 monofilament polypropylene suture. Two pairs of polytetrafluoroethylene neochords were implanted to provide support to the neo-free edge of the reconstructed part of the posterior mitral valve leaflet. The length of the neochords was adjusted during the water test.

7. The appropriate size of the annuloplasty ring was based on the size of the body of the anterior mitral valve leaflet. An annuloplasty ring size of 34 was selected. The ring was implanted in a standard fashion. The final water test revealed no residual leakage.

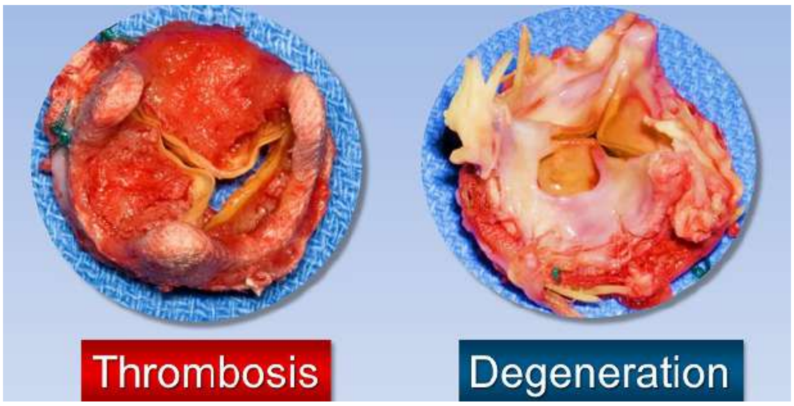
8. Intraoperative echocardiography demonstrated a good repair result with a mean pressure gradient of 3.5 mmHg, mild residual regurgitation, and good height of leaflet coaptation. The postoperative course was uneventful.

DAY 17 (24th of July 2024)

Bioprosthetic Mitral Valve Thrombosis

Today, I had a chance to watch an emergency case with Dr. Pelletier. The patient history was: 62-year-old female presented to the ED with a medical history of hypertension, mitral valve repair, mitral valve replacement, CHF, and anemia presented to the emergency department with a sudden onset of shortness of breath and central sternal pressure-like chest pain while she was moving furniture.

As the patient arrived she was found to be hypoxic, normally does not wear oxygen required up-titration to 5 L via nasal cannula. She had no history of smoking, COPD, or asthma. On physical examination breath sounds bilaterally with some mild coarse adventitious sounds were appreciated in the bases. An unremarkable cardiac examination was obtained without a frank murmur with no obvious jugular venous distention. She had trace lower extremity pitting edema. The patient denied any pleuritic discomfort though she does state that the symptoms were relatively sudden in onset. Her EKG was reassuring nonischemic, and paced rhythm without any evidence of ST segment elevation or depression to be concerning for ischemia. Workup was consistent with heart failure exacerbation with copious B-lines on ultrasound, bilateral pleural effusions on chest x-ray, and hypoxic respiratory failure. The patient initially stabled on a 6 L nasal cannula but she required escalation to BiPAP after her saturation started to fall to the mid-80s on the nasal cannula accompanied by increased work of breathing and tachypnea. Cardiac workup was otherwise without acute pathology. Troponin initially elevated at 161 but down-trended to 126. She had already received 324 mg of aspirin at home before presenting to the hospital. The predominant suspicion is that this is demand ischemia from hypoxia and heart failure. Labs were otherwise notable for elevated NP consistent with heart failure. Electrolytes were within normal limits. The patient does have mild leukocytosis to 14.8 but otherwise does not have any infectious symptoms and a chest x-ray otherwise more consistent with heart failure than pneumonia. There was no clinical evidence of DVT. There was no tachycardia, hypoxia better explained by pleural effusions and CT PE was deferred at this time. The patient was given a 40 mg furosemide with appropriate urine output. On reassessment several hours after initiation of diuresis, the patient was still mildly tachypneic on BiPAP. Given the concern for de-escalation from BiPAP with continued evidence of hypoxic respiratory failure and tachypnea, the case was discussed with MICU and the patient was admitted to MICU for further management.



The patient's oxygen continued to drift down, she is was not in any distress and actually felt comfortable while she was at rest but minimal movement caused exacerbation of symptoms. BNP and troponin were both elevated likely secondary to heart failure exacerbation. She was placed on noninvasive positive pressure ventilation for ventilatory support, she received Lasix, she continued to be treated aggressively, and was admitted to ICU.

The patient had been diagnosed with severe mitral stenosis secondary to a bioprosthetic valve that appeared to be very stenotic only 2 years after implantation. She had 2 previous cardiac surgeries including a sternotomy for mitral valve repair and a redo sternotomy for mitral valve replacement. Three days later of her admission, she deteriorated, needed to be intubated, and had significant inotropic support requirements. A transesophageal echo (TEE) on the weekend had suggested severe stenosis of the mitral valve likely secondary to clot formation, especially on the ventricular side.
She was taken urgently to the operating room. Under general anesthesia, the patient was prepped and draped appropriately. The right groin was explored and the artery and vein were identified. The patient was heparinized, and the artery was cannulated with a 17 Bio-Medicus cannula in the vein with a two-stage 25 French cannula advanced into the SVC under TEE guidance. The patient was placed on bypass.

The previous sternal incision was opened. The sternal wires were removed. The sternum was opened with an oscillating saw. Reentry into the sternum was uneventful. The heart was mobilized including the aorta and right atrium. The left and right pleural spaces were opened and drained with serous heart failure fluid. We added an SVC cannula, and we retracted the IVC cannula into the IVC. The aorta was cross-clamped and cold blood cardioplegia was given into the aortic root and the coronary sinus directly. The right atrium was opened. An interatrial incision was reopened. The exposure to the valve was excellent. There was a significant blood clot on the atrial side of the valve. This was all removed and sent for culture, microbiology, and pathology. We then proceeded to remove the valve, there was a significant amount of clot on the ventricular side of the valve. The previous pledgets were also removed. We sized it for a 31 mm valve. We tried to close the left atrial appendage but it was too close to the annulus, and we felt that it would compromise her ability to safely implant the valve therefore we left it alone. There was no clot in the left atrial appendage.

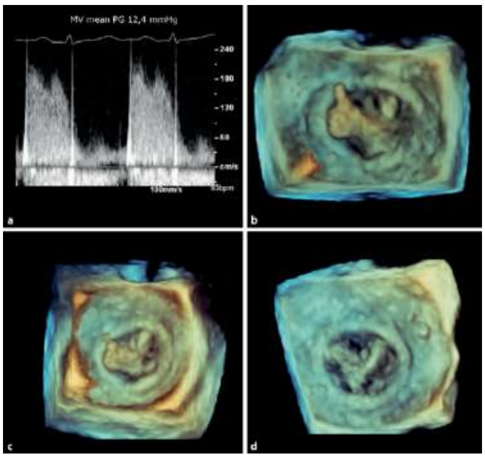
We placed multiple sutures of two Ethibond with pledgets on the atrial side. We passed them through the sewing ring of a 31 mm epic valve. It was lowered into position without difficulty and tied with core knots. Testing of the valve showed no insufficiency. The left atrium was de-aired and the interatrial septum was closed with running sutures of 3-0 Prolene. The right atrium was then closed with running sutures of 4-0 Prolene. A terminal hotshot was given and the cross-clamp was removed. A right ventricular pacing wire was placed along with 2 chest tubes.
We then proceeded to wean the patient from bypass. We had no difficulty weaning her from a mechanical support perspective, there was good right and left ventricular function.

However oxygen saturation quickly dropped into the low 80s, and despite all respiratory measures, it would not increase. We were not surprised by this given her lung status going into surgery. We quickly decided that we would place her on veno-venous (VV) ECMO. Under ultrasound guidance, we cannulated the left femoral vein and advanced the wire into the SVC under TEE guidance. We then advanced a 25 French venous cannula, that would serve as the inflow cannula, into the left femoral vein. We advanced the right femoral venous cannula into the SVC which would serve as a return cannula. We started her on CMO at 2 or 3 L/min and with this, her oxygen saturation quickly improved. We removed the femoral arterial line, we started protamine, and we had good hemostasis after 15 to 20 minutes. The sternum was closed with interrupted wires, the fascia was closed with O Vicryl subcutaneous tissues with 2-0 Vicryl and skin with Monocryl. The sponge instrument counts were correct at the end of the case. The patient was brought back to the ICU in stable condition, although in critical condition.

DAY 18 (25th of July 2024)

Interarterial Anomalous Right Coronary Artery

Today I had a chance to assist Dr. Pelletier in a really rare case. The patient was a 62-year-old male presented with a history of several episodes of dizziness, especially with activity who has been referred with an anomalous right coronary artery that appears to be causing symptoms and a mildly dilated ascending aorta. He had no history of chest pain, shortness of breath, chest tightness, or any symptoms of angina. He had a past medical history of gout, allergy, and hypertension. Physical examination and blood tests showed no abnormal findings. ECG showed sinus bradycardia with first-degree AV block. Stress ECHO showed stress-induced regional wall motion abnormalities and evidence of inferolateral hypokinesia at peak with significant dyspnea. Left ventricular function was normal, at peak stress, there was no increase in ejection fraction associated with inferolateral hypokinesia. Transthoracic Echo (TTE) revealed normal systolic function. The estimated EF was 55-60% without valvular abnormality and spectral Doppler showed an impaired relaxation pattern of left ventricular diastolic filling. A coronary angiogram showed a normal left coronary artery but the right coronary artery was very difficult to find; demonstrating no significant disease, origin was not well visualized. A coronary angiogram CT scan was helpful, showing a normal left coronary artery system with a slit-like opening for the RCA. RCA arose from the left and right commissure between the aorta and RV before rejoining its normal course. The patient was diagnosed with an anomalous right coronary artery with an ascending aorta dilation.

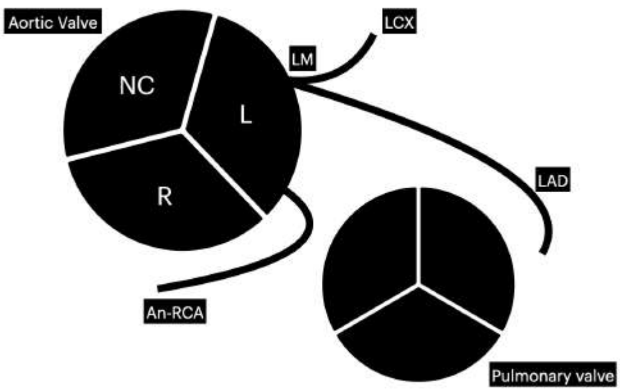


Based on a review of his symptoms and investigations, it was thought that he would benefit from the surgery. It was believed that this was now manifesting itself because the aorta has dilated (3.9 cm), stretching the coronary artery and reducing the size of the RCA ostium to a slit which would explain the late presentation. The surgical strategy would be a median sternotomy and either unroofing or the RCA vs detachment and reattachment of RCA vs CABG x1 with the RIMA to the proximal RCA.

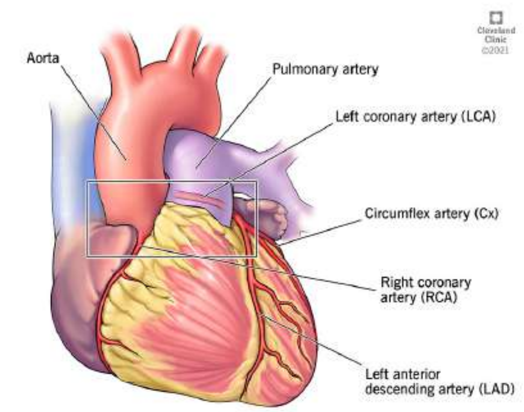
Because his aorta was dilated, we would also replace a part of the aorta with the need to replace the aortic root. Under general anesthesia, the patient was prepped and draped properly. A median sternotomy was performed, and the pericardium was opened and suspended. The distal ascending aorta and the right atrium were cannulated, and the patient was placed on bypass. The distal ascending aorta was crossclamped and cold blood cardioplegia was given into the ascending aorta and the coronary sinus retrograde. The heart was arrested in diastole.

The heart was retracted and a posterior pericardial window was done into the left pleural cavity. The aorta was transected approximately 1 cm below the cross-clamp, and the incision extended down to the sinotubular junction. The incision was then extended along the sinotubular junction and the right and left coronary ostia were identified.

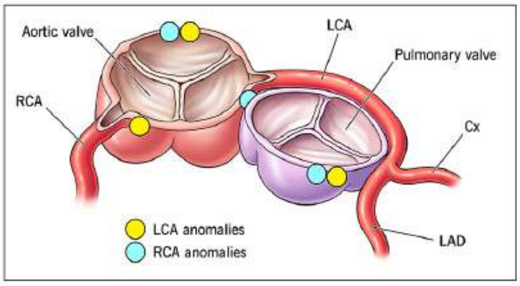
During surgery, the right coronary artery was found to be anomalous as described on the CT angiogram. It was wrapped around the anterior part of the aorta with the ostium located at the top of the commissure between the right and left coronary cusps. It was intramural inside the aorta for the last 1 cm. We were able to mobilize it over a distance of 3 to 4 cm, preserving at least 3 branches other than the main right coronary artery itself. We transected the proximal right coronary artery, and it measured approximately 4 mm in diameter. We then ligated the ostium with pledged sutures of 4-0 Prolene. We created a new hole in the right coronary sinus and anastomosed the right coronary artery to the aorta with 7-0 Prolene. We were able to pass a 4 mm probe into the right coronary artery. We then replaced the ascending aorta with a 30 mm graft, and both anastomoses were done with 4-0 Prolene. A terminal hotshot was given and the cross-clamp was removed under de-airing conditions. A right ventricular pacing wire was placed along with 2 chest tubes, 1 in the mediastinum and 1 in the left pleural space.



The patient was weaned from bypass without difficulty and with good biventricular function. We measured flows in the grafts on multiple occasions, before coming off bypass after bypass and after protamine. In all instances, we had flows of 80 to 120 L/min with a pulse index anywhere between 0.9-2.0, with diastolic flow in the range of 60 to 70%. All of these are excellent parameters and suggest that there was no concern with the patency of this graft.



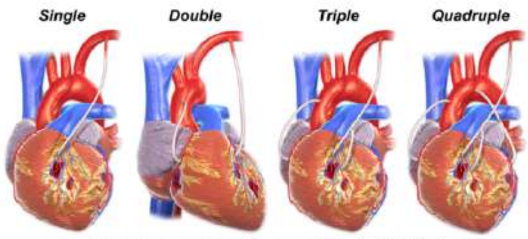
Possible Anomaly Locations



Visually, the only concern was that the right coronary artery, once we implanted, appeared to be taking an upward trajectory towards the right ventricle, but as noted above there was excellent flow, there was good right ventricular function, there was good inferior left ventricular function, there were no ST segment changes, and we documented flow as noted above. Protamine was given to reverse the heparin effect. The cannulas were removed and the cannulation sites were oversewn with 4-0 Prolene. When bleeding was satisfactory, the pericardium was closed with interrupted sutures of 2-0 Vicryl. The sternum was closed with interrupted steel wires, the fascia was closed with 0 Vicryl, subcutaneous tissues with 2-0 Vicryl, and the skin with Monocryl. Sponge instrument counts were correct at the end of the case. The patient was brought back to the ICU in stable condition.

DAY 19 (26th of July 2024)

On my last day here, I joined Dr. Ruda Vega at a CABG x 3 case. He did anastomoses between LIMA to LAD, RCA to SVC, and Circumflex to SVC. It was a really enjoyable case.



Coronary Artery Bypass Graft (CABG)

Farewell to the Cardiac Surgery Team

After the surgery, Dr Ruda Vega invited me to lunch with some of the surgeons including him, Dr. Gray, and Dr. Halim. We talked about my future plans and what I want from cardiac surgery. I wished Dr. Halim and Dr. Gray good careers and thanked both of them for teaching me so much while I was here.

They are both amazing surgeons and teachers. After lunch, we went to see some pre-operative patients with Dr. Ruda Vega after we checked their ECHO and Cath. CT images. He explained to the patients why they needed surgery and made it sound very comfortable for them. We were done in an hour then, I said goodbye to Dr. Ruda Vega and thanked him for everything. Of course I had to say goodbye to my favorite nurses as well so I went to the ORs. First I found Katie who gave me a warm goodbye hug, afterwards I found Momma D (that's what they called her around the hospital) who wished me the best in life but was quiet sad that I was leaving. After I was done saying my goodbyes I left the hospital for the very last time. It was a very educational and emotional journey for me, I loved everything about this place and I hope I get to come together with these amazing people again in the future! I am thankful to Dr. Sina Ercan for giving me this opportunity to be here and I am thankful for all the doctors or healthcare workers for making my journey enjoyable!

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